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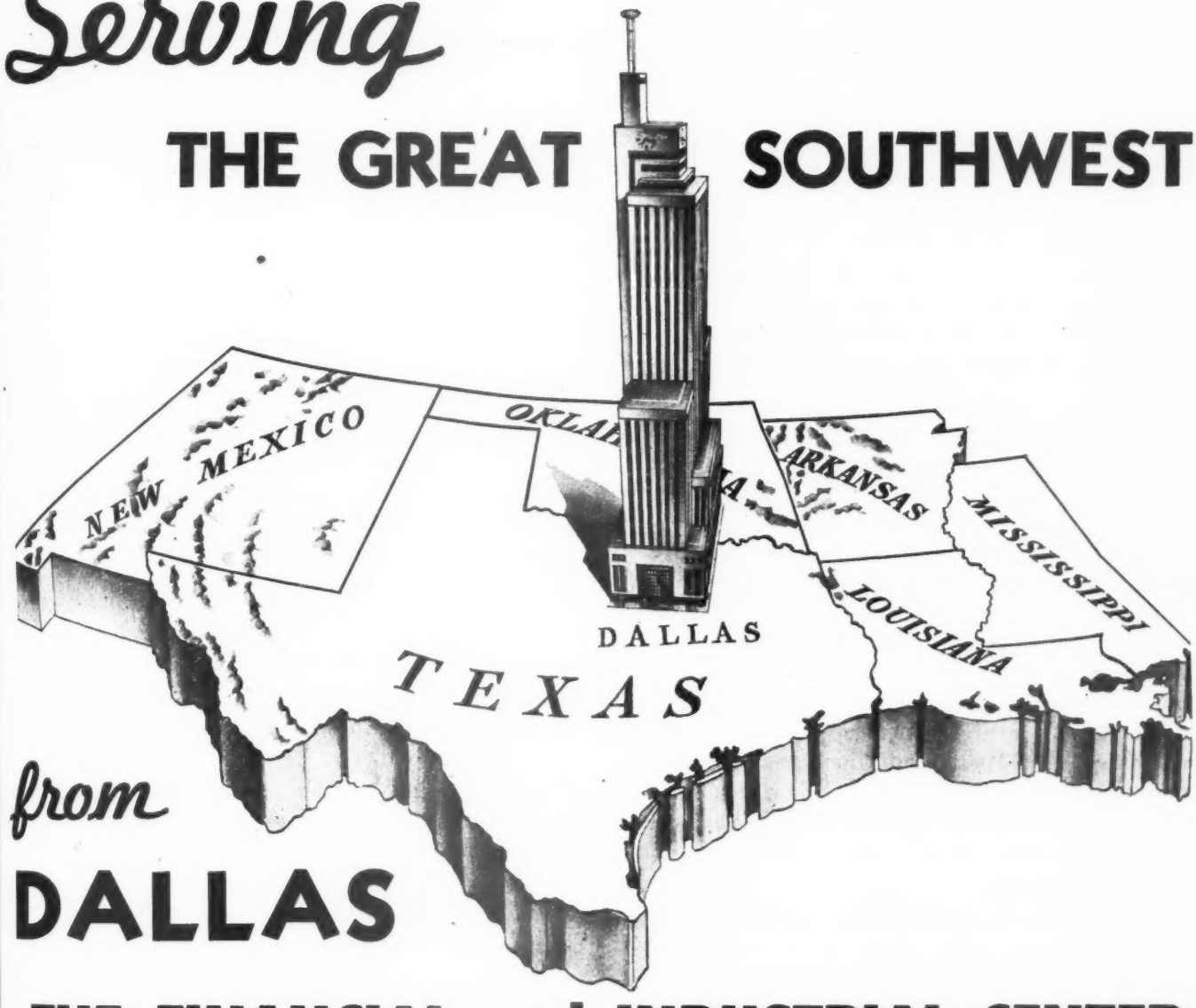

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The Course of Oil

by K. C. SCLATER

LIQUIDATING DOMESTIC RESOURCES

Preliminary estimates indicate that the average net cost of finding a barrel of oil during 1944 was about 41 cents, nearly five times the average net cost during the period 1935 to 1938. This abrupt rise in the finding cost of oil is especially significant at a time when nearly all oil fields in the United States are being produced at a rate near or above their optimum.

Aside from governmental restrictions and shortages of skilled help and critical materials, each of which has contributed in varying degree to the increasing cost of finding oil, the prevailing low price of crude oil is a potent deterrent to the intensive oil exploitation that the present situation demands. We have reached the point that, if the present rates of oil production are prolonged, irreparable harm to existing fields is inevitable. Despite this outlook, the oil industry has not faltered in its efforts to produce all the oil and refined products needed to fill the demands of war. There is the increased probability, however, that the time may not be far distant when we no longer shall be able to fill these demands from domestic sources and may even have to import oil for domestic needs.

The fact that foreign oil might have to be imported to meet domestic needs would not necessarily mean that our potential resources are lacking; it does emphasize, however, what the industry has for a long time been painfully aware of—the insufficiency of available domestic crude oil reserves. To remove this deficiency may take several years of intensive exploration and wildcatting.

Whether such a shortage of domestic crude might have been averted by a crude price increase is a moot point, and this issue has not daunted the industry's determination to fill all war needs. Experience and cost data reveal, however, that the cost of discovering and producing a barrel of oil today is much greater than the prevailing price of crude oil. In other words, the production branch of the industry is undergoing partial liquidation, for available domestic reserves of crude oil are being produced at a cost greater than that required to discover new reserves now so sorely needed. It is a sad commentary on the exploitation of a natural resource so vital as petroleum.

LESSON IN COOPERATION

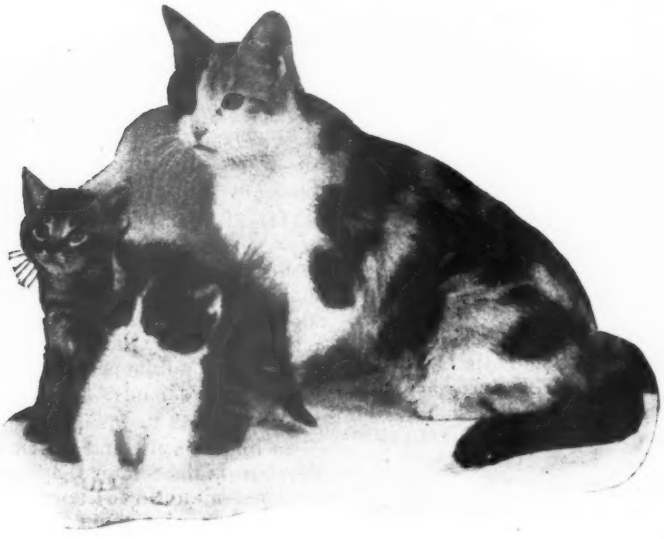
A marked departure from the usual procedure has been taken by oil operators in Mississippi in forming an Oil and Gas Engineering Committee for that state. It is a forward-looking step that carries much promise for oil operations in Mississippi; it is also an encouraging example of cooperation among operators. The function of the committee will be to obtain factual information on oil and gas operations and to gather engineering data on all fields in the state. This information will be compiled for the use of participating members and made available in convenient form for study and immediate application in the solution of field problems.

Mississippi is a young and also a potentially large producer of oil and gas. The organization of the duties of the committee is such that the data and studies will be purely objective in nature and cover every oil operation in the state, rather than any one field or group of fields. Herein it differs from engineering oil and gas committees in other parts of the country, with the possible exception perhaps of the state of New Mexico. In that state one engineering committee covers all fields being cooperatively developed. The work of the committee in Mississippi, however, is of a broader scope and its activities cover all operations from their inception regardless of whether or not operations are unitized.

Organization of a committee at this early stage of the state's oil development is an advantage. The sole purpose in gathering and compiling factual field data is to improve field operations that will lead to the greatest conservation of oil and gas and to their economic recovery. The information compiled will aid in the sound development and operation of fields and in the forestalling of malpractices that might lead ultimately to the dissipation of oil and gas resources.

Much thought has apparently gone into the formation and organization of this group. Being an engineering organization free from any political ties, its labors should result in the greatest benefit to Mississippi in prolonging the life of its oil and gas resources. Those responsible for initiating this progressive step are to be commended.

Cats to Kittens



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Scanning WASHINGTON'S OIL HORIZON

MILBURN PETTY

WASHINGTON. Stepped-up military requirements will place a heavy burden on the domestic oil industry during the months ahead but the Petroleum Administration for War is confident all demands can be met provided the industry is given the necessary manpower and materials.

Opening of foreign refineries will take up some of the load. A 35,000-bbl. refinery in southern France and a 30,000-bbl. plant in England are expected to go on stream before many months elapse. The new 50,000-bbl. Arabian refinery at Ras Tanura is scheduled for operation in the fall. Dutch East Indies refineries may be in our hands before the year is out.

Intensified drilling in the light crude fields of Venezuela and more production from the Middle East are part of PAW's programming.

Worldwide, there is between 150,000 and 200,000 bbl. daily of unused refining capacity available. Of this, 70,000 bbl. per day is in the United States—mostly skimming plants—with the bulk in California and the Middle West. Some idle California capacity is being started up now with West Texas crude coming in by tank car (which saves on tanker transportation to the Pacific war fronts). Transportation isn't available to get crude to the Mid-Western plants.

These idle inland plants, however, may be PAW's ace in the hole *IF* military authorities increase their 100-octane requirements again during 1945. Here's why:

PAW's program for 8 new catalytic cracking projects (four have been approved already by WPB) won't be operating until 1946. So they wouldn't be any help.

Some additional alkylate and base stock could be made if the feed stocks were available, such as light gas oil; kerosine or naphtha; straight-run gasoline or thermal-cracked gasoline and gas oil. But the only source of these feeds is civilian motor fuel and heating oils or new light crudes. (Feed stocks for the petroleum butadiene plants have already been turned back to 100-octane.) Civilian consumption has been cut to the bone, so that is out. Sweet crude production in the United States is at the maximum now.

But light crude from Eastern Venezuela could be brought in to the coastal refineries, releasing domestic crude for the idle inland capacity and transportation to get it to them (for example, the Big Inch pipe line could drop some off in the Middle West). These inland refineries could supply some of the gasoline and distillate fuel now going to interior points from coastal refineries, thus enabling them to keep this material for use as feed stocks for their catalytic crackers.

But there are many "IFs" in such a program, not the least being tanker availability to bring in the crude.

Another alternative, if military requirements should be upped, would be expansion of the light ends program. But that is unlikely. PAW has a sizeable program under way now and it is all earmarked in the program to meet presently-estimated requirements. About 35,000 bbl. per day was added to cycling and natural gasoline capacity during 1944, bringing the year end's total to about 300,000 bbl. per day. Another 25,000 to 30,000 bbl. per day is now under construction, all to be in operation by June. Besides this, PAW has five cycling projects held up until unitization of field operations can be worked out.

The 27,000-well drilling program for 1945 is an absolute "must" if the current production rate of crude oil (4,756,800 bbl. per day) is to be maintained. This output rate is the cornerstone of PAW's programming. If there is any deficit it will have to be made up with Venezuela crude.

MANPOWER AND MATERIALS. The petroleum industry's 1900 workers under 26 in production, refining, and foreign operations — previously deferred in the draft—seem to be faring better than the 26-29 group in Selective Service's accelerated call-ups. Each has been individually certified by PAW as critically essential. It would be impractical to apply the same 42-A Special procedure to the 26-29 group because there are so many more of them. Some local draft boards are calling up 26-29 men even though production, refining, and transportation have been classed as "critical" and therefore should be the last called.

It now appears that PAW will get better than 90 per cent of the 287,000 tons of steel for oil country tubular goods needed for the 6900-well program in the April-June quarter. For awhile, there was a threat to cut this allocation in half.

TIDELANDS. Industry representatives here are worried by reports that Secretary Ickes is about to yield to those in the Interior Department who have long urged steps to assert federal claim to submerged lands off the coast of California. (Interior is also eyeing with interest the leasing of Mississippi submerged, offshore lands by the state.) Reports persist that Ickes is about to accept a "public lands" oil and gas lease application on these California tidelands. The state would take it into court.

OIL TREATY. Prospects of the Anglo-American oil agreement hinge on the anti-trust law immunity provision. If a fight develops in the Senate, that provision will be the cause of it. Yet if there isn't anti-trust law protection, the companies will be reluctant to operate under the treaty. Right now, due to opposition from some quarters within the Department of Justice, the road ahead for the anti-trust clause doesn't look easy.

Ickes wants to keep alive his Petroleum Reserves Corporation until the oil agreement is approved, probably using the Arabian pipe line ghost as some kind of club over somebody, maybe the British. However, Senator Ed Moore, Oklahoma, plans to reintroduce his bill to kill PRC forthwith.

CRUDE PRICE STUDY. When OPA's refining industry advisory committee meets here March 15, OPA is expected to make it clear there is no possibility of a product price increase if OPA should find it necessary to allow a crude price advance. Discussion then will be on whether refiners can absorb a crude increase. Congressman Patman's Small Business Committee suggests subsidizing the "marginal" refiners who cannot absorb an increase. It is no secret that OPA doesn't want the responsibility of deciding which refiners can absorb, which cannot. Certainly, the refiners don't want a subsidy with all the red tape and government auditing and control involved. Instead, some refiners suggest that if a crude advance is allowed by OPA and product prices are unchanged, then it should be handled by expanding the present stripper well subsidy program.

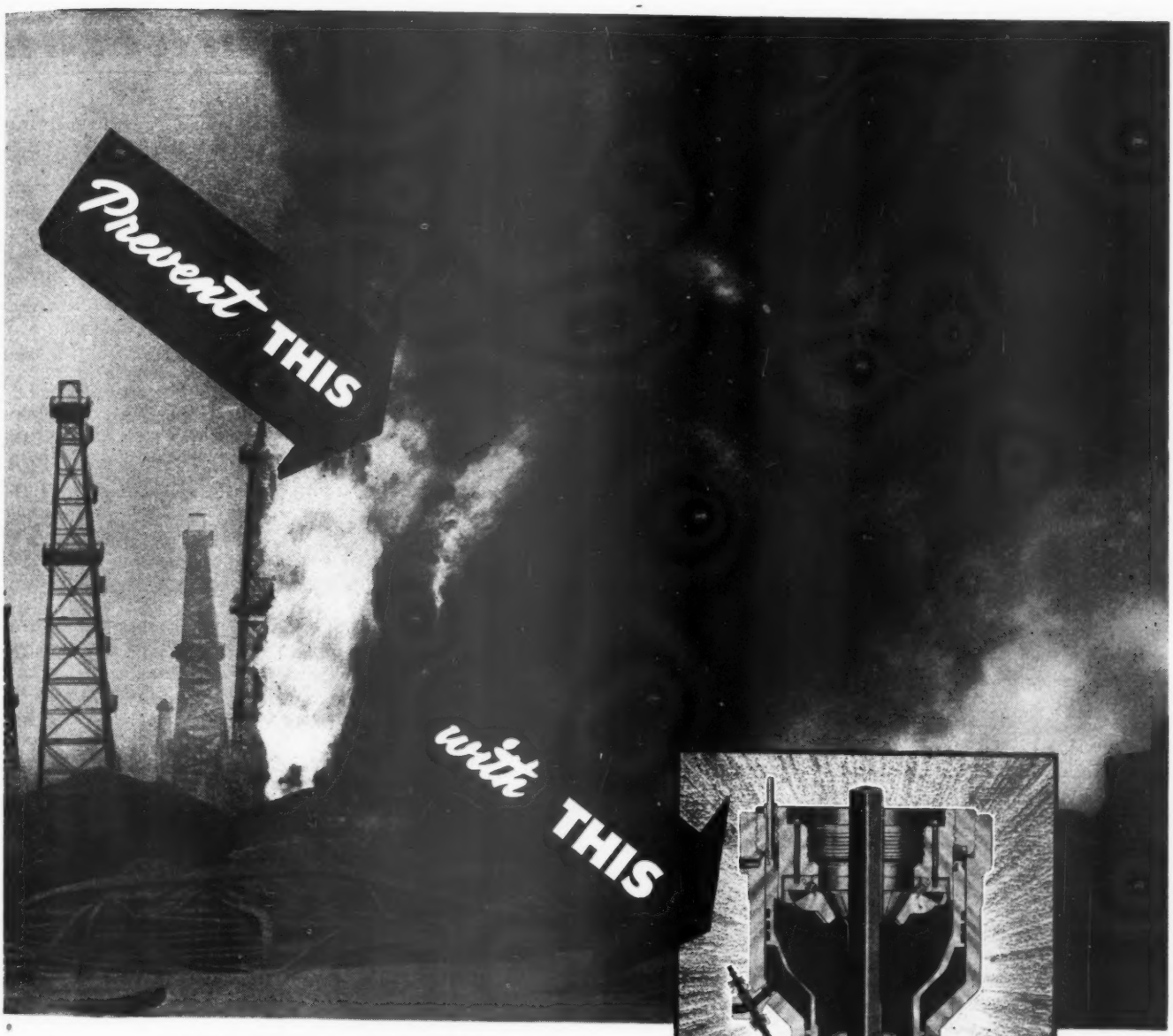
MORE WEST TEXAS CRUDE TO CALIFORNIA. PAW wants to increase to 50,000 bbl. per day the tank car movement of West Texas crude to California. Present authorization limit is 20,000 bbl. per day, which is expected to be reached soon. PAW has been advised there is more unused refining capacity in California that could be put on stream if the crude were available. This might bring the total to as much as 38,000 bbl. a day.

TEST OF PAW's PRODUCTION CONTROL PROGRAM. PAW's production control program, which operates in states without proration laws, seems headed for a test in California. A producer, who allegedly overproduced his quota, has been warned to cut back. Purchasers of his crude have been told to make sure that their takings in the aggregate total no more than the producer's quota. If this move fails to get the desired result, PAW plans to ask the Department of Justice to seek an injunction. If that is not forthcoming, PAW may ask Congress to put some "teeth" into its orders. PAW feels that if it doesn't enforce this production quota, then compliance with its other order in all branches of the industry may suffer.

New report begins

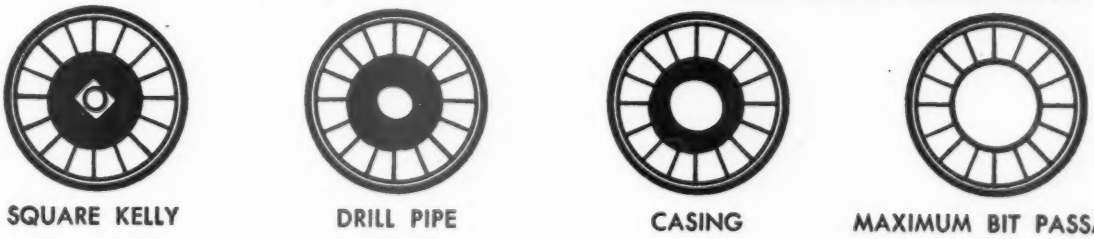
Milburn Petty, who contributes the material for this new feature from the Capitol, is one of the best qualified observers of political matters as they affect the oil industry. He has spent the last ten years as a Washington correspondent and news editor of the National Petroleum News and of Platt's Oilgram. He now edits his own publication, "Petty's Oil Letter."

"Scanning Washington's Oil Horizon" is an exclusive report and will be carried in *The Petroleum Engineer* each month.



HYDRIL TYPE "R" BLOWOUT PREVENTER

See how it closes off around all drill string members.



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National Petroleum Situation

RISE IN CRUDE DEMAND. Annual crude demand since Pearl Harbor has increased nearly 24 per cent. Bureau of Mines figures for 1942 and 1943 and preliminary data for 1944 follow:

	Total demand	Increase over 1942
1942	1,410,780,000	
1943	1,512,882,000	7.2%
1944 (Prel.)	1,746,060,000	23.8%

Crude demand in the first month of this year was 4,881,000 barrels daily, which is about 9 per cent above a year ago.

DRILLING RESULTS OFF. Well completions in January were 8 per cent under December. Under the new drilling quota for 1945 of 27,000 wells, January results were about 5 per cent below expectancy. Wildcat drilling in January was about 11 per cent below the quota and development completions were approximately 4 per cent behind schedule.

STOCKS LOWER. Stocks of both crude and refined products were reported lower at the close of January. Crude stocks dropped 755,000 barrels under December while all refined products showed a decline of 10,630,000 barrels. The reduction in refined stocks was influenced by heavy withdrawals from fuel oil storage in January. Preliminary data indicates transfers of crude to fuel storage were reduced and more than offset the decline in demand for fuel oil during the month.

GREATER GASOLINE YIELDS. A notable change in refining operations in January was an increase in the average gasoline yield to 41.3 per cent, against 40.8 per cent in December and 38.6 per cent a year ago. Thus, even though refinery still runs were reduced 52,000 barrels daily in January the production of motor fuel increased 8,000 barrels daily over December. Motor fuel demand, including aviation gasoline, is shown to have been .17 per cent above a year ago.

PEAK NATURAL GASOLINE OUTPUT. Natural gasoline production reached a new high in January of 9,300,000 barrels, representing an increase over a year ago of 16 per cent. It is of interest to find that the output of this product since the beginning of the war has been increased 35 per cent. In December, 1941, the average ratio of natural gasoline to total motor fuel was 11.9 per cent. In January, 1945, the ratio is shown to have increased to 13.6 per cent.

MORE CIVILIAN GASOLINE. A new breakdown of gasoline stocks is being compiled by the API to show changes in civilian motor fuel inventories. As of January 27, 1945, it was shown that civilian gasoline stocks amounted to 46,412,000 barrels, against 44,571,000 barrels a year ago.

Comparative Statistics, January, 1945

*All figures are computed on a Bureau of Mines basis.**

	Jan. 1945(p)	Dec. 1944(p)	Jan. 1944	This year to date	Last year to date	Per cent change
Wells drilling	4,315	4,430	3,077	4,315	3,077	+ 40
Total wells drilled	2,081	2,264	1,420	2,081	1,420	+ 47
Development wells	1,735	1,913	1,144	1,735	1,144	+ 52
Oil	1,068	1,186	855	1,068	855	+ 25
Gas	193	208	88	193	88	+119
Dry	474	519	201	474	201	+136
Per cent dry	27.3	27.1	17.6	27.3	17.6	+ 9.7
Wildcat wells	346	351	276	346	276	+ 25
Oil	46	52	29	46	29	+ 59
Gas	10	12	9	10	9	+ 11
Dry	290	287	238	290	238	+ 22
Per cent dry	83.8	81.8	86.2	83.8	86.2	— 2.4
Crude production	146,710	147,330	135,767	146,710	135,767	+ 8
Daily average	4,733	4,753	4,380	4,733	4,380	
Crude stocks	229,925	230,680	248,097	229,925	248,090	— 7
Days supply	47	47	56	47	56	
Crude demand†	151,300	150,832	138,303	151,300	138,303	+ 9
Daily average	4,881	4,866	4,461	4,881	4,461	
Natural gasoline production	9,300	9,104	8,021	9,300	8,021	+ 16
Daily average	300	294	259	300	259	
Motor fuel production	67,180	66,940	58,183	67,180	58,183	+ 15
Daily average	2,167	2,159	1,877	2,167	1,877	
Gasoline yield, per cent	41.3	40.8	38.6	41.3	38.6	+ 2.7
Motor fuel stocks	79,700	74,500	74,786	79,700	74,786	+ 7
Days supply	40	37	44	40	44	
Motor fuel demand	61,980	62,728	52,902	61,980	52,902	+ 17
Daily average	1,999	2,023	1,707	1,999	1,707	
Fuel oil stocks	77,415	89,750	83,160	77,415	83,160	— 7
Days supply	32	36	38	32	38	
Fuel oil demand	73,960	77,375	68,251	73,960	68,251	+ 8
Daily average	2,386	2,496	2,202	2,386	2,202	
Refinery still runs	143,075	144,670	133,161	143,075	133,161	+ 7
Daily average	4,615	4,667	4,296	4,615	4,296	
All refined stocks	234,100	244,730	227,324	234,100	227,324	+ 3
Days supply	44	44	48	44	48	

*Unless otherwise stated all figures represent thousands of barrels.
†Domestic and foreign.

Economic Position of U. S. Petroleum Industry

January, 1945

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	2,200	2,081	95
Production (daily crude output)	4,830	4,733	98
Refining (daily still runs)	4,660	4,615	99
Stocks (crude and refined)	568,000	464,025	82
Price of crude (per bbl.)	$1.97	$1.22	62

Crude Prices by States for January, 1945

U. S. average	$1.22	Louisiana	$1.20
Texas	1.23	Arkansas	1.25
California	1.07	New Mexico	1.04
Oklahoma	1.17	Mississippi	1.10
Kansas	1.17	Illinois	1.37
		Other States	1.89

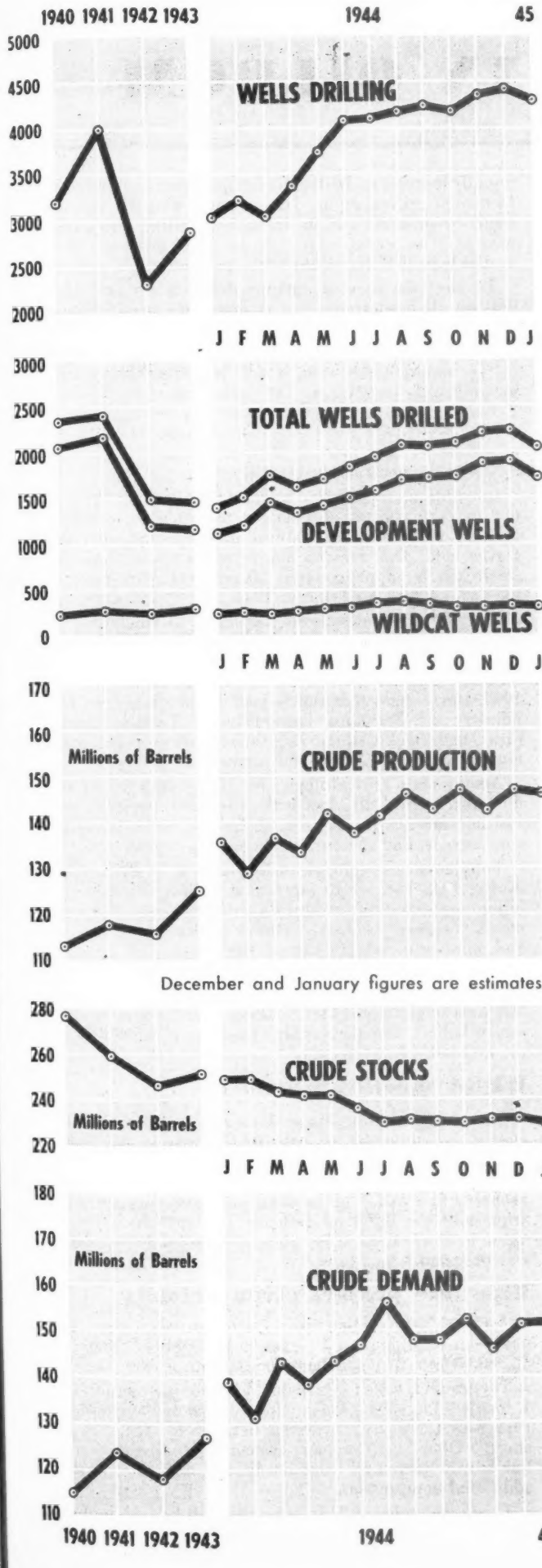
Basic crude prices

Oklahoma-Kansas (36 gr.)	$1.17
Texas Gulf Coast (36 gr.)	1.40
East Texas	1.25
West Texas (36 gr.)	1.04
Calif., Signal Hill (26 gr.)	1.11
Pennsylvania Bradford	3.00

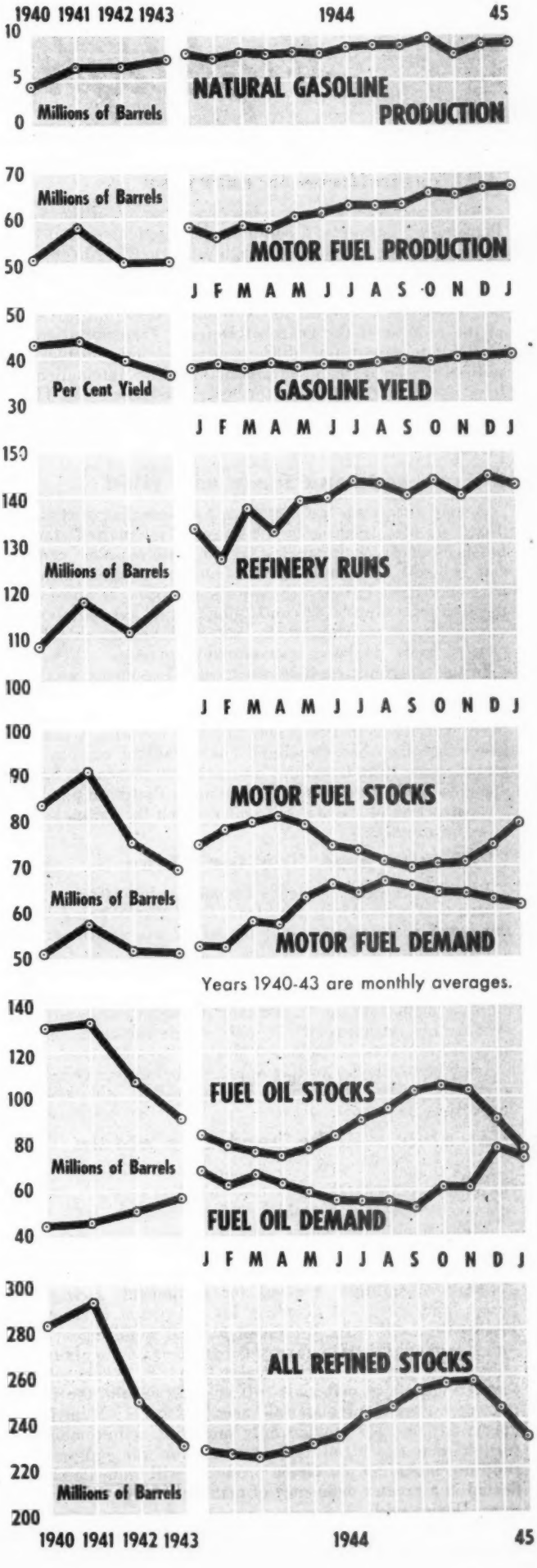
Drilling and Production Statistics by States

	Jan. 1945(p)	Dec. 1944(p)	Jan. 1944	This year to date	Last year to date	Per cent change
Total wells drilled	2,081	2,264	1,420	2,081	1,420	+ 47
Texas	552	530	315	552	315	+ 75
California	221	172	148	221	148	+ 49
Oklahoma	195	174	75	195	75	+160
Kansas	112	142	127	112	127	— 12
Louisiana	81	67	44	81	44	+ 84
Arkansas	13	25	14	13	14	— 7
New Mexico	41	40	23	41	23	+ 78
Mississippi	26	18	13	26	13	+100
Illinois	169	207	131	169	131	+ 29
Other States	671	889	530	671	530	+ 27
Wildcats drilled	346	351	276	346	276	+ 25
Texas	126	100	109	126	109	+ 16
California	22	12	16	22	16	+ 38
Oklahoma	34	22	19	34	19	+ 79
Kansas	35	44	28	35	28	+ 25
Louisiana	16	7	13	16	13	+ 23
Arkansas	4	5	3	4	3	+ 33
New Mexico	8	12	5	8	5	+ 60
Mississippi	10	8	11	10	11	— 9
Illinois	36	56	28	36	28	+ 29
Other States	55	85	44	55	44	+ 25
Daily crude production	4,737	4,753	4,380	4,737	4,380	+ 8
Texas	2,111	2,130	1,896	2,111	1,896	+ 11
California	886	895	813	886	813	+ 9
Oklahoma	370	366	326	370	326	+ 13
Kansas	253	276	270	253	270	— 6
Louisiana	353	354	345	353	345	+ 2
Arkansas	81	82	79	81	79	+ 3
New Mexico	103	102	113	103	113	— 9
Mississippi	48	50	43	48	43	+ 12
Illinois	214	206	219	214	219	— 2
Other States	318	292	276	318	276	+ 15

***Does not include input wells. (p)—Preliminary.
§No change since prices frozen. Prices do not include subsidies.



December and January figures are estimates.



Years 1940-43 are monthly averages.

Highlights IN OILDOM

API committees to carry on

All committees in the division of production of the American Petroleum Institute will continue their activities until the 25th annual meeting is held in Chicago some time in November, wartime transportation conditions permitting, according to an announcement by the board of directors. The 25th annual meeting originally was scheduled for November, 1944, but was deferred at the request of the Office of Defense Transportation due to wartime transportation difficulties and hotel shortages. Committees in the division of production thus automatically will have a two-year instead of the usual one-year term. They will conduct their business by mail for the rest of 1945, whenever possible, although some special committee meetings may be necessary, it is announced.

Submerged land lease suit filed

A suit to test the validity of a long-standing section of the Texas statutes relating to the lease of submerged state lands has been accepted for review by the state supreme court. In a suit brought by Grayburg Oil Company against Land Commissioner Bascom Giles, the question is brought up of whether the 39th legislature's act controlling oil and gas rentals of state-owned "bays, marshes, reefs, salt water lakes, or other submerged lands" includes state-owned river beds.

In the Grayburg vs. Giles case, the oil company was granted its motion for leave to file a petition for mandamus seeking to compel Giles to renew an oil and gas lease on 280 acres of the Pecos River bed in Pecos and Crockett counties. Giles has refused, holding that Grayburg has defaulted on payment of rentals since 1928. Grayburg contends that no rentals have been due since 1928. Grayburg's motion notes that both parties want a construction of the statutes under which the company feels it owes no rentals.

2000-mile pipe line for China

Leo T. Crowley, foreign economics administrator, has revealed that a 2000-mile lend-lease pipe line is being laid into the interior of China to aid the allied air attack on Japan. Crowley told the house foreign affairs committee this month that the pipe line, being constructed through combined American, British, Chinese, and Indian manpower and resources, "will increase many fold the 15,000 tons per month that once moved over the old Burma road." It will "enable the combined forces of the United Nations to mount new and greater offensives from China," he testified. Crowley appeared before the committee to urge a one-year extension of lend-lease that otherwise would lapse June 30.

Materials will be harder to obtain

More difficulties will be encountered in obtaining materials for oil industry operations in 1945 than last year Petroleum Administrator for War Harold L. Ickes advises.

Administrator Ickes said that in general the 1945 demand for petroleum industry materials will exceed the supply and that a number of important items are becoming more critical.

Increased military demand for equipment, lack of manpower, and increased demands for petroleum equipment are factors that will make it difficult to meet requirements for oil industry materials this year, the administrator explained.

Deputy Petroleum Administrator Ralph K. Davies points out that the supply of materials will be tight despite the fact that present estimates of materials needed for petroleum industry operations in 1945 include only minimum requirements. Any further increases in military demands for war equipment and supplies, including petroleum products, will immediately be reflected in a greater deficiency of materials for petroleum operations, Davies said:

"The key to the material shortage is, of course, the military situation. Military demands for critical materials are continually increasing. Dislocation of manpower hampers the manufacture of critical items. These factors plus the industry's construction program and its expanding drilling programs for the year point to increasingly tight stocks of materials that will be available in 1945 for oil industry operations."

To meet the present wartime demands for petroleum products on all battlefronts and at home, the production of crude oil in the United States must continue at the high rate of approximately 4,700,000 bbl. a day throughout 1945, Davies said.

"To maintain this rate, it will be necessary to drill 27,000 new oil wells in 1945, or 3000 more than were drilled in 1944. According to present estimates the new drilling program calls for approximately 2,014,000 tons of carbon and alloy steel or about 16 per cent more steel than estimated requirements for this type of operation during 1944."

In addition, the petroleum industry will spend about $52,000,000 in each quarter of 1945 for the domestic construction of refinery units and for natural gasoline and cycling plants, Davies said. This construction program on the basis of carbon steel calls for approximately 20 per cent more materials than the 164,000 tons used during 1944.

Miscellaneous operations during 1945, including the construction and maintenance of transportation and marketing facilities, will call for about 174,000 tons of steel. About 170,000 tons of steel was used in this type of petroleum operations in 1944. Davies said that the following materials used by the oil industry are becoming more critical: Tubular goods, structural steel, steel castings, large steel plate steel forgings, aluminum sheet, copper, lead, and lumber.

Among more critical items are: Heavy duty trucks and heavy duty truck tires, all electrical equipment, certain valves, control instruments, pumps, certain boilers, pressure vessels, pressure gauges, and some miscellaneous instruments.

Tubular goods including drill pipe will be extremely critical during 1945 because of increasing military demands upon tubular goods facilities and growing domestic and foreign requirements, the deputy administrator said. Demand for rock bits and tool joints continue to exceed the supply but increased production of these items can be expected by the middle of 1945.

"Large steel forgings are critical and the supply situation of this item is getting tighter," Davies said. "There seems no reason to believe that the supply of this item will improve during the first half of 1945."

WPRA meeting canceled

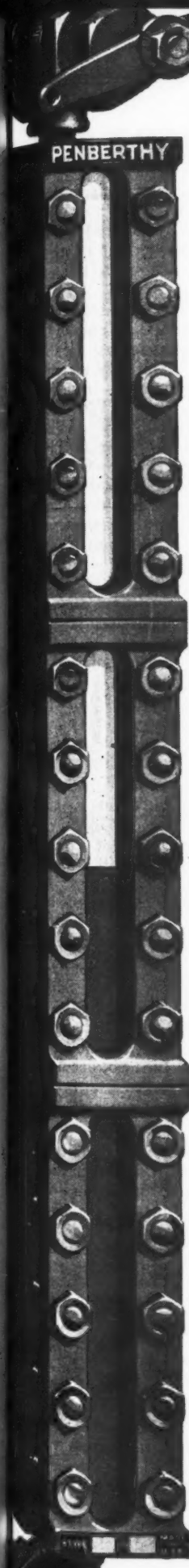
The annual meeting of the Western Petroleum Refiners Association, scheduled to be held in Chicago in April, has been cancelled, John C. Day, secretary, announces. Instead, directors of the association will hold a meeting in Tulsa, Oklahoma, probably in April. The meeting was canceled in line with the request of the Office of Defense Transportation for industry not to hold meetings unless they are absolutely necessary to the war program.

Pipe line project given priority

A $9,000,000 pipe line project to increase deliveries of natural gas from Oklahoma and Texas to the Ohio-Michigan area by 50,000,000 cu. ft. a day has received top priority rating.

The project, which is scheduled for completion by November 1, involves increasing the capacity of one of Panhandle Eastern Pipe Line Company's two lines between the Hugoton gas field and the Ohio Fuel Company system. Operating pressure of the line will be increased from 500 lb. to 600 lb. by installation of additional compressors.

Thirty-two miles of 24-in. pipe line will be laid on the eastern end of the line to permit delivery of the additional gas into the Ohio system near Muncie, Indiana, and Maunee, Ohio.



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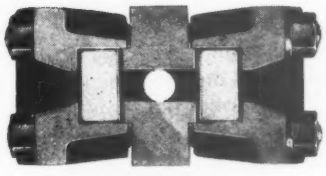

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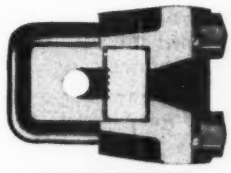

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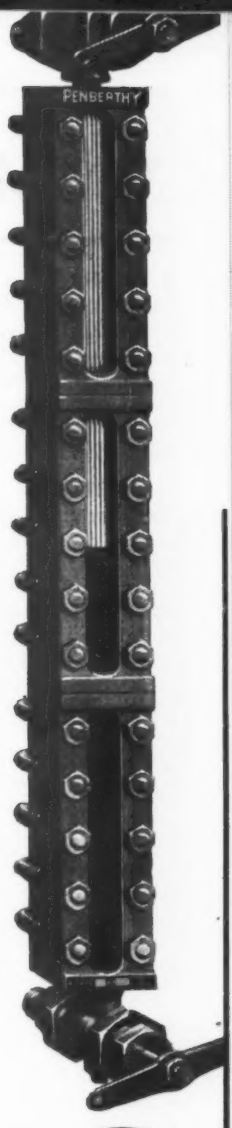

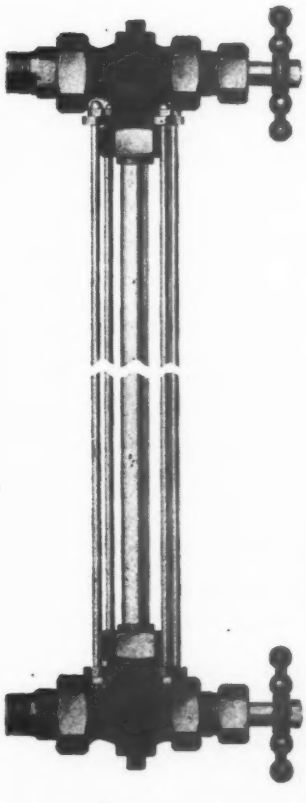

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MAJOR *Oil Field* ACTIVITIES

▸ **CALIFORNIA.** Brought in at a depth of 2300 ft., Shell Oil Company's discovery at Kirby Hill has given California a new gas pool. The well produces 4,000,000 cu. ft. of gas a day under restricted flow. It is 9 miles north of Pittsburgh near Suisan Bay. Engineers said they had indications of a major gas field.

▸ **KANSAS.** M. H. Watts and Jeff T. Boucher have given Comanche County a new gas pool with the opening of No. 1 Boisseau, a wildcat in C SE NW 27-31-18w. The discovery topped the Mississippi lime at 5068 ft. Tests showed considerable free gas.

Houser Drilling Company has opened a new pool in Saline County with No. 1 Carlin, NE SE SW 13-15-3w. The well is 3 miles southwest of the Salina field. It has an initial rating of 77 bbl. of oil daily from the Viola lime at 3280 ft. The well is Kansas' third discovery for 1945.

▸ **NEW MEXICO.** Skelly Oil Company has opened a new pool in Lea County, southeastern New Mexico, with its No. 2 Steeler, 17-23s-37e. The discovery is situated 6 miles southwest of Clear Fork and east of the Monument pool. At 5462-5520 ft. on a 30-minute test, the well showed a steady flow and recovered 93 ft. of gas-cut mud. The crew is drilling deeper.

▸ **LOUISIANA.** The Iota area of Acadia Parish has a new pool with the opening of Union Sulphur Company No. 1 Medlenka, 11-8s-2w. It flows 100 bbl. of 32-gravity oil daily. Production is from perforations at 9664-76 ft. with total depth at 9692 ft.

Pure Oil Company has opened in Vermilion Parish a deeper sand production with the completion of No. 2 Benoit, 5-12s-2w, on the southwest flank of the West Gueydan dome. The discovery flows 168 bbl. of 38.1-gravity oil daily from perforations at 10,060-70 ft. Pure opened production in this area late in 1944 with No. 1 Benoit, which produced from 9615-23 ft.

Atlantic Refining Company has given St. John Parish a new discovery with its B-1 Lutchen Moore. From 10,254-66 ft., the well makes 318 bbl. of 42.21-gravity oil a day. Total depth is 11,626 ft.

Humble Oil and Refining Company C-1 Wilberts Corporation, 77-8s-8e, has been brought in, making 325 bbl. of oil and 525,000 cu. ft. of gas a day. The discovery is in the Bayou des Glaise dome in Iverville Parish, southern Louisiana. Gravity is about 37 deg. The well produces through perforations at 9850 ft. with total depth at 10,581 ft. Until late last year this section was known as a salt dome that had produced oil in no considerable volume.

Phillips Petroleum Company has opened a new gas pool in western Caddo Parish with No. 1 Moneyhan, NE NW 5-18-16w. The well was drilled to 6500 ft. and casing set at 6065 ft. On a drill-stem test in the Travis Peak at 5800 ft. the well produced half oil and half water.

Biggest gasser

The largest gasser yet discovered in Oklahoma is Phillips Petroleum Company and Kerlyn Oil Company No. 1 Classen, CNW SE 22-12-4w, southeast of Bethany and about 5 miles south of the West Edmond pool. It was perforated opposite the Bois D'Arc of the Hunton lime between 7154-7200 ft. and made gas at an official rate of 12,000,000 cu. ft. per day. Good sources, however, said that the well, tested by every known method of gaging gas, showed a potentiality of approximately 100,000,000 cu. ft. a day. The producer is in Oklahoma County.

▸ **TEXAS.** A major discovery for the lower valley has been opened by Humble Oil and Refining Company. It is No. 1 McDermott, a wildcat, in Zapata County. Production is 193 bbl. of oil and water a day, the crude oil being 34.33 gravity.

A new pay for Howard County has been opened by the Hyer and Yates No. 1 Clay, 155-29, W&NW survey, with the deepening of an old well. The producer was drilled from 1828 ft., where it had been completed in 1929, to 2840 ft. where the new pay zone was discovered. It was completed at 2900 ft. for 25 bbl. of oil daily. It likely will lead to a general deepening program in that area, operators believe.

The Glenn H. McCarty No. 1 Wilson opened the first oil pool in the upper Gulf Coast in 1945. It is on the John Bradley survey, Brazoria County. Through perforations from 8698-8710 ft. the well makes 350 bbl. of oil per day. Total depth is 10,806 ft. The discovery well was drilled on a 120-acre farmout from Stanolind Oil and Gas Company to McCarty.

Maguire Industries No. 1 Berndart, 1474 TE&L survey, A-900, is a new pool opener for Young County. Located 3 miles north of Jean in the northern part of the state, the discovery flows 25 bbl. of oil an hr. from 4373-4403 ft.

A new Permian lime producer for southeastern Cochran County has been opened by the Honolulu Oil Company. It is No. 1-A-9 Hudson, 2½ miles southwest of the Slaughter pool. The well was completed for 111 bbl. of oil daily pumping from plugged back total depth of 5120 ft. Pay is from 5046 ft. to the total depth.

The No. 1 W. E. House, discovery by Tide Water Associated Oil Company in the Ricardo area of Kleberg County, flowed 195 bbl. of 37.2-gravity oil daily on a 6-hr. test. Production is from perforations in the Frio sand at 7266-68 ft.

Atlantic Refining Company has indications of a new field opener in Tyler County where its No. 1 Houston Oil Company-American Republics Corporation, made 900 ft. of oil and 1000 ft. of water in a 4-hr. test. The well is in BBB&C survey, 3, East Texas. Total depth is 9015 ft. with production from perforations at 8432-60 ft.

Wharton County has a new gas well with The Texas Company No. 1 Matzke, 26, I&GN, 2 miles southwest of Peace. The discovery has an estimated 58,000,000 cu. ft. of gas production daily through perforations from 5779-84 ft. Total depth is 6435 ft.

▸ **MISSISSIPPI.** The No. 2 McDowell, a Pure Oil Company gas-condensate well, opens a new pool for the southern part of the state. It is in Adams County, 12-6n-3w. It gaged 5 bbl. of 51.7-gravity condensate an hr. on initial test. Production is from the top of the Tuscaloosa sand.

▸ **WYOMING.** A third important oil strike by Sinclair Wyoming Company in the last three months has been made in Carbon County. It is No. 1 Milton Coffman, NE NE 21-26n-89w on the Bailey Dome unit. At a total depth of 5195 ft. in the Sundance sand, the well makes 462 bbl. of oil in 24 hr. The well is 4 miles southeast of the Lost Soldier field.

▸ **OKLAHOMA.** Cities Service Oil Company No. 1 Mariner, NW NE NW 6-22-3w, Garfield County, showed as a promising discovery with 10,000,000 cu. ft. of gas between 4884-5074 ft. in the Bartlesville and Wilcox sands. Operators drilled to the Arbuckle limestone, 5247-62 ft., where on a 30-min. test it had 2500 ft. of 40-gravity oil. The well is between the town of Garber and the Garber oil field.

Magnolia Petroleum Company opened an active two-county play for southern Oklahoma with its discovery No. 1 Jones Heirs, C NW SE 21-1n-4w. The well, in eastern Stephens County between the Doyle, Robberson and Scholom Alechem areas, made 10 bbl. of oil an hour while cleaning. It is producing from 5525-50 ft.

No. 1 Anneler, CSW NE 26-6-1w, a Magnolia Petroleum Company discovery in southern Cleveland County, swabbed 101 bbl. of oil, without water, from perforations in casing between 6075-83 ft. Total depth is 7035 ft. in the Wilcox sand.

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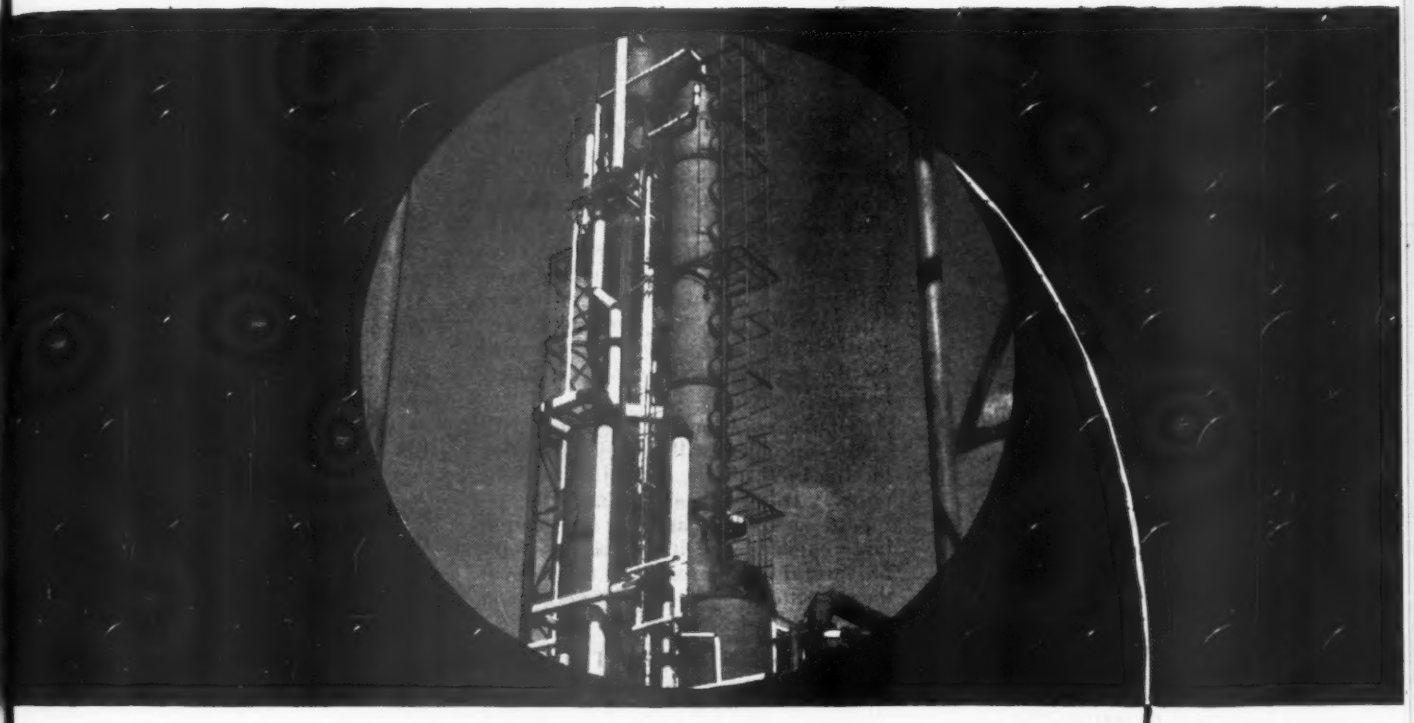

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MAJOR *Pipe Line* ACTIVITIES

▸ **90-MILE LINE.** Utah Oil Refining Company has been granted permission by WPB to construct a 90-mile, 6 in. crude line from Rangely pool, Rio Blanco County, Colorado, to Craig, Moffat County, Colorado. Connection will be made in Craig County with an existing line from Iles, Colorado, to Wamsutter, Wyoming. The line will be laid with new pipe and will have a capacity of 6250 bbl. daily. Construction is scheduled to begin in April with completion in July.

Construction to start

Interstate Oil Pipe Line Company will begin construction of its line from the Mississippi oil fields to Baton Rouge, Louisiana, some time early in March. The company will lay 121 miles of 8-in., 10-in., and 12-in. line that will have a capacity of 18,000 bbl. of crude oil daily. Completion of the entire project is due in June or July.

▸ **LITTLE BIG INCH RECORD.** An average of 179,000 bbl. of petroleum products were pumped daily in the first 12 months of operation of the 1475-mile Little Big Inch pipe line running from Beaumont, Texas, to Linden, New Jersey, PAW has disclosed. The Little Big Inch, largest products line in the world, has carried more than 65,000,000 bbl. of refined petroleum products since it began operation on January 26, 1944, despite the fact that the line handled mostly heating oil and all pumping stations were not completed until September, 1944.

Commenting on its first year's operation, the statement said: "The Little Big Inch pipe line is one of the country's most potent weapons of war, aimed like a gigantic rifle at the heart of Germany. It has carried millions of barrels of high-octane gasoline to fuel our fighting planes. It has transported tons of diesel oil to drive our submarines, landing craft, and other light vessels. In addition, it has carried home-treating oil and other petroleum products required for essential domestic use."

▸ **PIPE LINES AFTER WAR.** The recent additions to the nation's expanding pipe line network will bid strongly in competition with the postwar oil traffic, according to conclusions reached from a study just completed of war-built pipe lines and the postwar transportation of petroleum by Sam G. Spal of the Interstate Commerce Commission's bureau of transport economics and statistics. It is reasonably certain that these new lines with lower cost than those of the railroad will carry a considerable volume of traffic formerly moved by tankcar, the study asserts. Particularly is this true in the southern and north central states where railroads have a good business in transportation of refined oils. Tank trucks, operating from new terminals in these and other areas, will supplement the pipe lines, thereby further reducing the volume available for the railroads.

It is also asserted that some of the new pipe lines will divert traffic from tankers, particularly in the case of the Plantation, Southeastern, and Portland lines. The first two lines have terminals at or near large cities at a considerable distance from the coast. Shipments by tanker to the coastal ports plus rail or truck movement from the ports, formerly the chief means of supplying a large inland area, will prove more costly than the direct shipment by pipe line and truck. The Portland line was specifically designed for the purpose of reducing the tanker haul to Montreal.

"Of the government-owned lines, the greatest problem will be faced in fitting the Big Inch and the Little Inch into the postwar transportation set-up," the re-reports says. "They are long lines and of large capacity and it will be necessary for several oil companies to use them if they are to be successfully operated in oil service."

▸ **LINES NEAR COMPLETION.** Gulf Refining Company's 63-mile 8-in. crude oil pipe line, a PAW project, is expected to be ready for service by March. Forty-two miles of the line being laid from Keystone-Ellenburger field to Midland, Texas, is completed.

Another PAW project, the 30 miles of 12-in. loops being strung between Crane and Houston, Texas, is completed. All pipe has been received and strung by Texas-New Mexico Pipe Line Company, which is building the line.

▸ **PIPE LINE COURSE.** The history and care of pipe lines will be featured in a new course now offered in East Texas. The course, under the sponsorship of the API committee on vocational training and the state board for vocational training, will be given at the Greggtown community building and at Kilgore Junior College.

The course will include a complete study of pipe lines and fittings, construction and mainatenance, soil corrosion and pipe protection, operation of lines, oil tanks, strapping, tanks, gaging tanks, and pumping stations. Also featured will be a steady of the maintenance of pumping station machinery, capacity of oil pipe lines, and communication systems used by pipe line companies.

▸ **LINES FOR WAR.** Pipe laying is completed on Ohio Oil Company's 105-mile 8-in. products line from Robinson, Illinois, to Indianapolis, Indiana, PAW has reported. The line is ready for operation. The Robinson pump station is almost completed but the Indianapolis station will not be ready until March.

Reports on other PAW projects are as follows:

Colonel Beacon's 35-mile 4-in. and 6-in. products line from Everett to Dracut, Massachusetts, has 38 per cent of the line strung, 43 per cent of the ditch dug, 37 per cent of pipe welded, and 35 per cent laid.

All work on the pipe line outlet by General Petroleum Corporation of California for crude from Elk Hills United States Naval Reserve to refineries at Los Angeles, California, has been completed. The new 9-in. 8-mile line from Elk Hills to Midway laid by Union Oil Company of California has been finished and in operation since October 27, 1944. The Texas Company's 58-mile 10-in. line from Elk Hills to Cottonwood is completed and has been water-tested satisfactorily.

▸ **SPLIT STOCKS.** Panhandle Eastern Pipe Line Company directors have voted to split the company's common stock on a two-for-one basis. Action on the stock split-up took place after the sale by Phillips Petroleum Company of the major portion of its 25 per cent common stock interest in Panhandle Eastern. Phillips sold 150,000 of its 202,163 shares in the company, retaining a 6½ per cent interest in the line.

Sale of Phillips holdings was arranged by top executives of Panhandle Eastern. The purchasers were individual and institutional investors, all of whom are either stockholders of Panhandle Eastern or the Missouri-Kansas Pipe Line Company, which owns the largest single interest in the line.

The proposal to split the common stock will be submitted to the stockholders for approval at their annual meeting in March.

Oil to Arabian mainland

A pipe line outlet to transport oil from the Arabian mainland to Bahrein Island is being constructed by the Arabian-American Oil Company, half and half owned subsidiary of Standard Oil Company of California and The Texas Company. The refinery on Bahrein Island is being enlarged and improved. Special story in this issue, page 119.

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MAJOR *Refining* ACTIVITIES

▸ **GIANT PLANT IN OPERATION.** The new $20,000,000 Defense Plant Corporation 100-octane gasoline plant operated by Standard of California was dedicated at Richmond, California, recently. The new installation, with a capacity of several thousand barrels daily, makes the refinery one of the world's largest producers of 100-octane fuel. According to the War Department the plant will turn out enough high-powered gasoline to fuel a "substantial force" of B-29 Super Fortresses daily for the round trip from Saipan to Tokyo.

Construction was begun several months ago and was rushed to completion. Direct access to tanker loading facilities gives the new plant high strategic value. In addition, refinery barrel loading facilities have been expanded so that a large portion of the output can be transported in easily handled metal drums.

The central structure in the plant is the thermofor catalytic cracking and treating unit, which is 238 ft. high. There are two units, one of which cracks lower grade petroleum products by means of the new "bead" catalyst; the other upgrades the gasoline produced in the first operation by subjecting it again to the action of the catalyst. From this double treatment comes a stock that is almost equivalent to final 100-octane in quality. It must, however, be blended with other stocks before it is ready for the bomber's

Standard is operating the 100-octane plant under lease agreement with Defense Plant Corporation. Construction was sponsored by the PAW. Equipment process designing with the exception of the catalytic cracker, was by the California Research Corporation, a subsidiary of Standard. The catalytic cracker was designed by Bechtel-McCone Corporation, which engineered and constructed the plant.

▸ **LARGEST UNIT OPERATING.** The world's largest single fluid catalytic cracking unit has started operation at the Avon refinery of the Tide Water Associated Oil Company, according to L. F. Bayer, vice president in charge of manufacturing. This massive unit has a charging capacity of more than 750,000 gal. of gas oil per day. The importance to the war effort of the cracking plant and other units included in the project is attested by the interest in its early completion manifested by the army, navy, and PAW. It produces raw materials and other products used in the manufacture of 100-octane fuel.

Associated's high-octane gasoline production was substantially increased when the turning of a valve started the oil into the new giant unit that towers more than 200 ft. in the air. The main construction of this plant for contacting catalyst and oil at high temperatures was performed by C. F. Braun and Company of Alhambra, California, who also designed the unit with the assistance and cooperation of the engineers of Universal Oil Products Company of Chicago, Illinois, and of Tide Water Associated. The Universal Oil Products Company is licensor of this process.

▸ **REFINERY NEARS COMPLETION.** A new 50,000-bbl. a day refinery is nearing completion at Ras-Tanurah on the Persian Gulf north of the island of Bahrein. It is being built by United States engineers for the Arabian-American Oil Company, owned half and half by Standard Oil Company of California and The Texas Company.

▸ **ACCIDENTS DECREASE.** Accidents at Sun Oil Company's Marcus Hook refinery, where more than a billion gallons of high-octane gasoline have been made since Pearl Harbor, have fallen off 16 per cent since the start of a safety campaign last June. The record was achieved despite an increase of 1,382,063 hr. worked at the refinery during the campaign period as contrasted with the previous months of the year. This represented a 29 per cent increase in hours of exposure. The record was even more difficult to achieve when it is considered that there were 1871 new employes added to Marcus Hook refinery, whereas 1456 were released for various reasons.

▸ **REFINERY GROUP NAMED.** Members of the committee appointed by OPA to make a survey of costs of refining crude oil will hold their first meeting early in March, OPA has announced. The meeting was originally scheduled for February 20. The committee consists of 11 major oil refiners and 11 independent refiners. It includes specialists in refinery production, economics and marketing.

Members of the committee are:

W. S. Zehrung, president, Pennzoil Company, Oil City, Pennsylvania; W. H. Bennett, vice president and treasurer, Frontier Fuel Oil Corporation, Buffalo, New York; Paul G. Blazer, president, Ashland Oil and Refining Company, Ashland, Kentucky; Max M. Fisher, vice president, Aurora Gasoline Company, Detroit, Michigan.

C. L. Henderson, president, Vickers Petroleum Company, Inc., Wichita, Kansas; John W. Boatwright, manager, sales research department, Standard Oil Company (Indiana), Chicago, Illinois; D. P. Hamilton, president, Root Petroleum Company, Shreveport, Louisiana; Roland V. Rodman, vice president, Bay Petroleum Corporation, Denver, Colorado.

C. A. Johnson, chairman, Socal Oil and Refining Company, Huntington Beach, California; W. H. Beekhuis, assistant comptroller, Standard Oil Company of California, San Francisco, California; L. T. Cramer, manager, sales administration, Continental Oil Company, Ponca City, Oklahoma; Sidney A. Swensrud, vice president, Standard Oil Company of Ohio, Cleveland, Ohio.

B. L. Majewski, vice president, Deep Rock Oil Corporation, Tulsa, Oklahoma; Neil Buckley, Taylor Refining Company, Taylor, Texas; R. L. Tollett, president, Cosden Petroleum Corporation, Big Spring, Texas; Stewart P. Coleman, head, economics department, Standard Oil Company of New Jersey, New York.

Horace G. Dale, manufacturing department, Shell Oil Company, Inc., New York City; C. F. Salzer, assistant to general auditor, Gulf Oil Corporation, Pittsburgh, Pennsylvania; William L. Stewart, Jr., executive vice president, Union Oil Company, Los Angeles; J. S. Worden, manager refining operations, The Texas Company, New York City; M. E. Foster, Phillips Petroleum Company, Bartlesville, Oklahoma; Harry H. Fuller, manager bulk sales, Sinclair Refining Company, New York City.

▸ **CARTHAGE CYCLING PLANT.** The Chicago Corporation, Corpus Christi, Texas, parent company of Tennessee Gas and Transmission Company, has announced plans to construct a cycling plant in the Carthage gas field, Panola County, Texas. The plant will have a capacity of 150,000,000 cu. ft. a day, according to the announcement, and there will be a supporting field development and a pipe line program. Ten wells will be drilled on about 18,000 acres of recently acquired leases.

▸ **SMALLEST CATALYST UNIT IS SUCCESS.** The smallest commercial fluid catalyst cracking unit in the world has completed a successful 65-day run in actual service and promises to be of much significance in the field of catalytic cracking for small refinery operations. The unit is situated in the Frontier Refining Company, Cheyenne, Wyoming. It has a charging capacity of 2600 bbl. daily of fresh gas oil. Authorities consider the test results as going far to prove that catalytic cracking is practical for the small refiner.

Although fluid catalyst cracking is a vital means of producing fighting aviation gasoline, it has been used almost exclusively on a large scale. Designing a small unit presented special problems. W. R. Newman, Frontier vice president, in the current issue of the company's publication, tells of operations of the unit. He gives two fundamental innovations introduced in design of the unit: (1) Holding pressure on the regenerator, which allows it to be placed approximately on a level with the reactor, thereby reducing overall height of the structure, and (2) a specially designed scrubber to recover catalyst from the regenerator gas, in place of a much more costly precipitator installed in larger units.

THE Petroleum Engineer

FEBRUARY, 1945

COST OF REPLACING PETROLEUM UNDERGROUND RESERVES HAS QUADRUPLED SINCE 1940

By **H. J. STRUTH**, *Petroleum Economist*

EXCLUSIVE Most informed geologists and engineers in the petroleum industry agree that the United States is not in any danger of running out of oil in the near future. There is no little concern, however, over the fact that the oil industry has in the last five years spent tremendous sums in the search for new oil fields and the diminishing size of resulting discoveries has quadrupled the unit cost of new oil found.

Preliminary data for 1944 indicate that the oil industry found by initial estimates about 955,000,000 bbl. of new reserves at a total exploration cost of $478,254,000. On a net, working interest basis the cost per unit was approximately 58.5 cents. This compares with an average finding cost in the period 1935-38 of 13.8 cents per bbl. As many of the new fields discovered last year may be expected to increase in volume of reserves added by extensions and revisions of initial estimates, it is likely that last year's oil discoveries will ultimately be in the order of about 1,355,000,000 bbl., or 400,000,000 bbl. greater than initial estimates. On this assumption, it is apparent that the cost per unit on a working interest basis may prove to have been about 41.3 cents. This compares with an average net finding cost in the period 1935-38 of about 8.3 cents per bbl.

Although it is necessary to account for all the oil added to the underground inventory, including extensions to previously found fields and revisions in earlier estimates, to arrive at the approximate cost per unit each year, the relationship of finding cost to actual discoveries credited to each year has been of startling significance since 1935. Fig. 1 shows that the peak of new oil found during this period, after crediting extensions and revisions to years of original discovery, was 1937. Since then the quantity of new oil added to reserves each year has shown a precipitous decline, from 2,529,000,000 bbl. to only 630,000,000 bbl. last year. The latter figure includes projected revisions in and extensions to initial discoveries. During this ten-year period the cost of finding oil is shown to have increased fourfold.

Oil inventory shows depletion after 1939 with all extensions and revisions credited to discovery year.

Exploratory effort in 1944, as measured by the number of wildcat wells drilled and the number of dry holes drilled in efforts to develop new and previously discovered producing areas, reached the highest level in the last ten years. Last year the industry drilled a total of 7637 exploratory wells, as compared with 5231 drilled in 1935. Analysis of exploration costs for 1944 shows that the industry spent for drilling, including equipping producing wells, more than $192,000,000. Other costs, including leases, geological, geophysical, and overhead exceeded $286,000,000. The approximate division of exploration costs in 1944 was as follows:

U. S. exploration expenditures, year 1944

Drilling and equipping cost (7637 wells)	$192,070,000
Cost of acquiring and carrying leases, including land department	184,387,000
Geological and geophysical expense	54,932,000
Overhead and general office expense	46,865,000
Total cost	$478,254,000

Analysis of oil finding costs for the last ten years is presented in Table 1. It was deemed advisable to compute unit finding costs on an initial and a revised divisor basis. It is obvious that initial estimates of reserves discovered cannot be considered the true divisor in determining the cost of finding oil. Experience proves that credits to previously discovered oil fields must necessarily be made each year, with the result that first costs are reduced to the degree that credits are allocated to original discovery periods. If we use the first estimates of reserves discovered in 1944 as a divisor in computing finding cost, the result is 58.5 cents per bbl. When consideration is given to the definite possibility of subsequent upward revisions, however, the divisor becomes greater and the final cost may necessarily be reduced to 41.3 cents per bbl. Although unit costs may be subjected to several subsequent revisions, due to credits for underestimates of previously found oil fields, it is be-

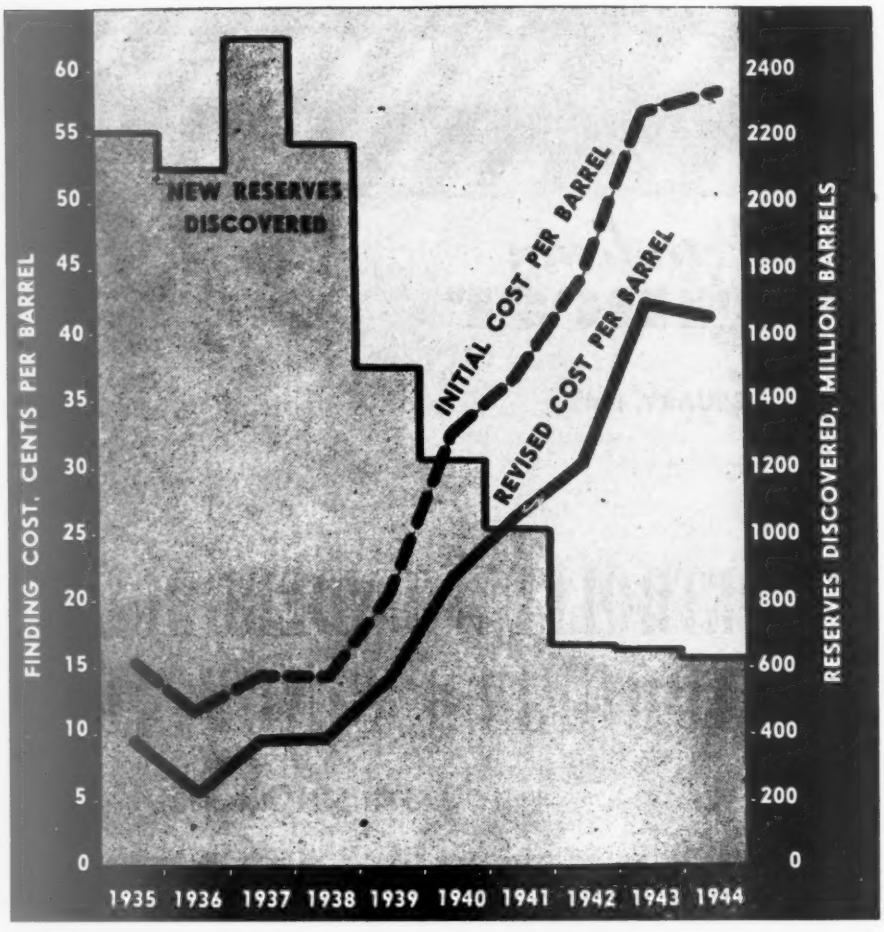

FIG. 1. COST OF FINDING OIL AND QUANTITY OF RESERVES FOUND.

The cost of finding oil is now four times what it was between 1935 and 1938. On the initial reserves discovered the cost per barrel last year was over 58 cents. In anticipation of subsequent upward revisions in discoveries the revised cost per barrel is expected to be above 41 cents.

lieved that the accompanying analysis of finding costs represents an accurate measure of conditions that have prevailed in the search for oil over the last ten years.

Table 1 shows also that the cost per exploratory well has doubled within the last ten years. In 1935, the total exploratory expenditures per well drilled amounted to $31,000. Last year the cost per well was $62,623. It should be noted that drilling costs, including completed producing wells and all dry holes drilled, constituted last year about 40 per cent of the total amount spent by the industry for exploration. The average drilling cost per exploratory well last year was about $25,000, whereas all other costs attendant to the search for oil added about $37,000 per well. The relatively low drilling cost per well reflects the fact that a majority of the exploratory wells were dry holes, which average about $20,000. Many wildcat wells drilled last year cost $50,000 or more.

Constantly increasing costs of finding new sources of oil supply in the United States make it evident that the cost of replacing oil withdrawn from underground reservoirs is materially greater than in former years. Particularly significant in this connection is the fact that the oil industry has been withdrawing crude from reserves in substantially greater amounts than the rate at which new supplies have been found. Since 1940, production of crude oil has exceeded new oil discoveries to the extent of 3,127,000,000 bbl. To replace this huge quantity of oil withdrawn from the underground reservoir at today's materially increased costs will necessarily involve tremendously increased expenditures for exploratory effort. This is particularly true when consideration is given to the fact that the rate of new oil reserve discoveries, including extensions and revisions, is only about 30 per cent of the rate recorded between 1935 and 1938.

Table 2 presents an analysis of replacement costs, showing the cumulative effect of finding costs for oil discovered in excess of productive requirements and subsequent costs incurred by replacement of oil produced in excess of reserve discoveries. The facts show that between 1935 and 1939 new reserve discoveries exceeded productive requirements to the extent of 4,756,000,000 bbl. The cumulative finding cost of this oil, on a working interest basis, amounted to $364,878,000, or an average unit cost of 8.9 cents. During the next five years, 1940-44, the industry entered a period of shortage between production and discoveries, making it necessary to replace withdrawals from the underground reservoir at substantially greater unit costs.

The year 1940 marked the first deficit between reserves discovered and production since 1933. Beginning with a shortage in discoveries of 117,000,000 bbl., succeeding years rolled up a constantly growing deficiency until it reached 3,127,000,000 bbl. at the end of last year. By projecting beyond 1944 to bring the cumulative oil replacement figure up to the total surplus recorded between 1935-39, it is necessary to add a total of 1,

TABLE 1

Approximate cost of finding oil in the United States.

1935-1944, inclusive

(All barrels in millions—money in thousands)

Year	Initial reserves found (a)	Working interest (85.5%) (b)	Revised reserves found (c)	Working interest (85.5%) (d)	Exploratory wells drilled (e)	Total drilling cost (f)	Lease and overhead cost (g)	Total cost (h)	Initial cost per bbl. (h-b)	Revised cost per bbl. (h-d)	Average expenditure per well (h-e)
1935	1,220	1,043	1,970	1,684	5,231	$ 57,639	$104,620	$162,259	$ .155	$ .096	$ 31,000
1936	1,763	1,507	3,713	3,175	5,671	63,414	113,420	176,834	.119	.056	31,200
1937	1,929	1,649	2,929	2,504	6,900	85,320	151,800	237,120	.143	.095	34,400
1938	1,854	1,585	2,704	2,312	6,453	81,750	141,966	223,716	.141	.097	34,700
1939	1,450	1,240	2,100	1,795	6,732	90,177	161,568	251,745	.203	.140	37,400
1940	1,020	872	1,520	1,300	7,032	102,644	182,832	285,476	.327	.220	40,600
1941	980	838	1,380	1,180	7,388	125,075	185,221	310,296	.370	.263	42,000
1942	779	666	1,129	965	6,123	121,302	172,602	293,904	.441	.305	48,000
1943	862	737	1,162	993	6,703	169,222	252,140	421,362	.571	.424	62,862
1944 (p)	955	817	1,355(r)	1,158(r)	7,637	192,070	286,184	478,254	.585	.413(s)	62,623

(a) New field discoveries and extensions to previously discovered fields.
(c) Includes allocations of subsequent revisions in first estimates.
(e) Wildcat producers and all dry holes drilled in exploration and development.
(f) Costs include equipping wildcat producers.
(g) Includes cost of acquiring and carrying leases, geological, geophysical, and overhead costs.
(p) Preliminary.
(r) Provides for anticipated upward revision of about 400 million bbl.
(s) Probable effect of subsequent revisions in reserve estimates in 1944.

ADDED TO OR WITHDRAWN FROM RESERVES, MILLION BARRELS

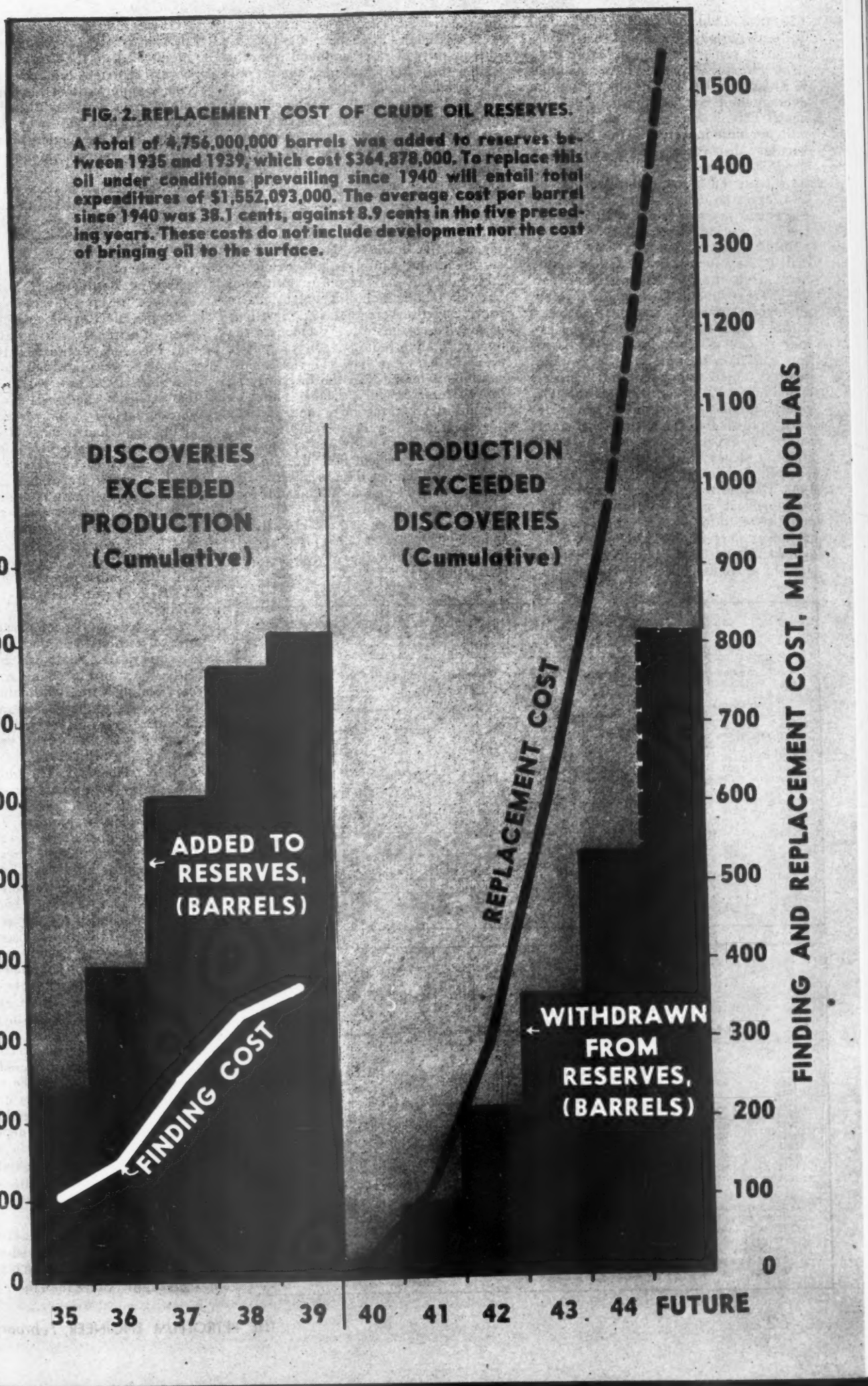
FIG. 2. REPLACEMENT COST OF CRUDE OIL RESERVES.
A total of 4,756,000,000 barrels was added to reserves between 1935 and 1939, which cost $364,878,000. To replace this oil under conditions prevailing since 1940 will entail total expenditures of $1,552,093,000. The average cost per barrel since 1940 was 38.1 cents, against 8.9 cents in the five preceding years. These costs do not include development nor the cost of bringing oil to the surface.
DISCOVERIES EXCEEDED PRODUCTION (Cumulative)
PRODUCTION EXCEEDED DISCOVERIES (Cumulative)
ADDED TO RESERVES, (BARRELS)
WITHDRAWN FROM RESERVES, (BARRELS)
FINDING COST
REPLACEMENT COST
ADDED TO OR WITHDRAWN FROM RESERVES, MILLION BARRELS
FINDING AND REPLACEMENT COST, MILLION DOLLARS
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FUTURE

629,000,000 bbl. All factors being equal for both periods, it is found that the cumulative replacement cost of oil withdrawn from reserves will have amounted to $1,552,093,000. During this period the average unit cost is shown to be 38.1 cents. This is more than four times the cost per unit incurred in the period of surplus discoveries. Fig. 2 presents graphically the marked changes that have occurred between the two periods and leaves no doubt of the fact that replacement costs are now at the highest levels in the industry's history.

In 1936 the oil industry only had to drill 1.53 exploratory wells to find a million barrels of new reserves. In that year the average quantity of oil discovered per exploratory well amounted to 654,735 bbl. In 1944, however, it was necessary to drill 5.63 exploratory wells to find a million barrels and the average quantity of oil found per well had declined to but 177,425 bbl. (See Table 3). Efforts to find new reserves last year were rewarded to the degree that final results are expected to increase the total quantity of new oil found to 1,355,000,000 bbl., against 1,162,000,000 bbl. in 1943. Despite the greater concentration upon wildcat operations last year, the quantity of oil found in new field discoveries was only about 235,000,000 bbl., against 282,000,000 bbl. in 1943. Extensions to previously discovered fields and prospective upward revisions in last year's estimates are expected to increase the quantity of reserves found from this source to 1,120,000,000 bbl., against only 880,000,000 bbl. in 1943.

Fig. 2 emphasizes the sharp decline in new discoveries over the last ten years and shows the effect of greater exploratory drilling activity upon the cost per well. During this period the quantity of reserves proved each year declined 67 per cent whereas the average expenditure per well increased 100 per cent.

It is generally agreed in the oil industry that the quantity of proved oil reserves in the nation is approximately 20,000,000,000 bbl. If the quantities of new oil found, including extensions to previously discovered fields and revisions of previous estimates, are added to the underground inventory each year, it is evident that there has been an almost continuous increase in the inventory of proved reserves since the beginning of the industry. At the beginning of 1944 the Committee on Petroleum Reserves of the API reported the nation's proved reserves at 20,064,000,000 bbl. On the basis of preliminary data on reserve discoveries in 1944 and accounting for last year's production it is estimated that the inventory on January 1, 1945, will be about 20,639,000,000 bbl. This is an all-time peak, despite the record-breaking production of 1944.

TABLE 2

Analysis of oil replacement costs.

Year	New oil found (millions)	Crude oil produced (millions)	Surplus or shortage (millions)	Cumulative surplus or shortage (millions)	Working interest (85.5%) (millions)	Finding cost per bbl.	Total finding cost (thousand $)	Cumulative cost (thousand $)
1935	2,300	997	+1,303	+1,303	1,114	$ .096	$106,944	$106,944
1936	2,100	1,100	+1,000	+2,303	855	.056	47,880	154,824
1937	2,529	1,279	+1,250	+3,553	1,069	.095	101,555	256,379
1938	2,180	1,213	+ 967	+4,520	827	.097	80,219	336,598
1939	1,501	1,265	+ 236	+4,756	202	.140	28,280	364,878
Period of surplus	10,610	5,854	+4,756		4,067	.089	$364,878	
1940	1,236	1,353	— 117	— 117	— 100	.220	$ 22,000	$ 22,000
1941	1,015	1,402	— 387	— 504	— 331	.263	87,053	109,053
1942	665	1,387	— 722	—1,226	— 617	.305	188,185	297,238
1943	652	1,503	— 851	—2,077	— 728	.424	308,672	605,910
1944	630	1,680	—1,050	—3,127	— 898	.413	370,874	976,784
Future			—1,629	—4,756	—1,393	.413	575,309	1,552,093
Period of replacement	4,198	7,325	—4,756		—4,067	.381	$1,552,093	

TABLE 3

Results of exploratory effort.

Year	Exploratory wells drilled (a)	Reserves discovered* New fields (b)	Reserves discovered* Extensions and revisions (c)	Total	Wells per million bbl.	Reserves found per exploratory well
1935	5,231	950	1,020	1,970	2.65	376,601
1936	5,671	850	2,863	3,713	1.53	654,735
1937	6,900	929	2,000	2,929	2.36	424,493
1938	6,453	810	1,894	2,704	2.39	419,030
1939	6,732	341	1,759	2,100	3.21	311,943
1940	7,032	286	1,234	1,520	4.63	216,155
1941	7,388	430	950	1,380	5.35	186,789
1942	6,123	260	869	1,129	5.42	184,387
1943	6,703	282	880	1,162	5.77	173,355
1944 (p)	7,637	235	1,120(r)	1,355	5.63	177,425

(a) Includes wildcat producers and all dry holes drilled in exploration and development.
(b) Initial estimates—new pool discoveries.
(c) Revisions in estimates are credited to years of original discovery; new field discoveries and extensions are credited to current years.
(p) Preliminary.
(r) Provides for subsequent revisions in 1944 estimates.
*Millions of barrels.

If we credit to each year only the quantities of reserves found in new fields and credit back to the years of original discovery all extensions and revisions, it becomes apparent that the peak of proved oil reserves was established in 1939. In that year, it is shown by the allocating method that the underground inventory of proved reserves amounted to 23,945,000,000 bbl. Thus, instead of adding to our reserves each year since 1939, we have actually depleted the underground inventory to the extent of 3,127,000,000 bbl.!

Fig. 4 compares the underground reserve inventory as reported by the Committee on Petroleum Reserves and the adjusted reserve inventory, which reflects the effect of allocating back to the years of original discovery all extensions and revisions. Between 1916 and 1929 the curves were in rather close conformity. Since 1929, however, it is apparent that extensions and revisions became important factors in the reserve discovery picture and had a marked effect upon the revised reserve inventory. The degree to which earlier reserve inventories had been underestimated is shown by the columns representing the quantities that have been allocated back to years of original discoveries. Particularly significant is the fact that the peak of extension and revisions was made during 1935 and 1936. Subsequently the quantities allocated to previous years has grown smaller.

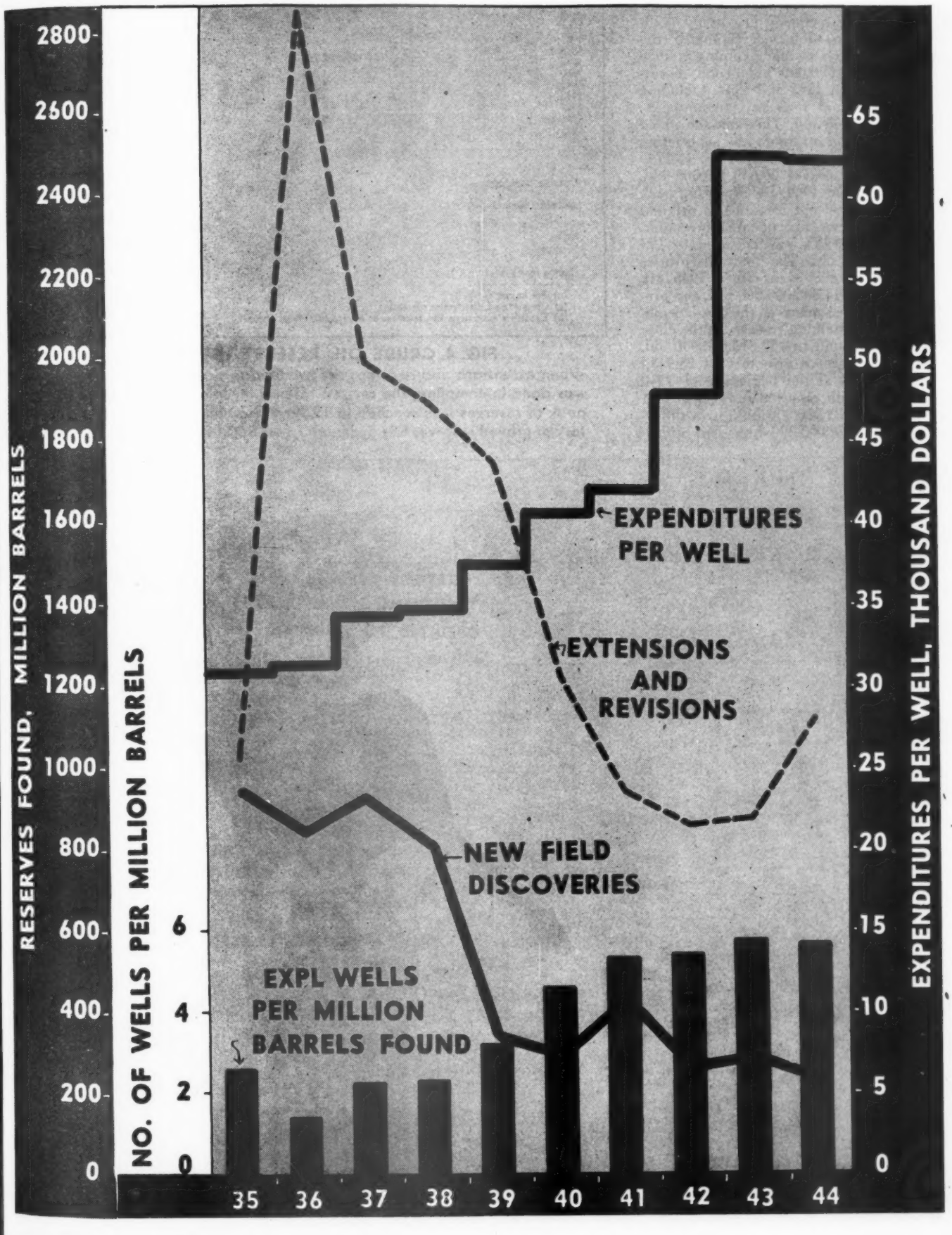
Table 4 shows the comparative reserve inventories plotted on the chart and presents other related data, which are graphically shown in Figs. 5 and 6. In the five years ending with 1930, culminating in the discovery of the East Texas field, the ratio of reserves discovered to crude oil produced was 3.3 to 1. In the last four years ending with 1944 the ratio had declined to 0.5 to 1. The ability of the oil industry to provide productive requirements through new reserves discovered in the four war years, 1941-1944, is shown to have been only one third as effective as it was in the preceding ten years, when the ratio was 1.5 to 1.

The effect of allocating oil discovery extensions and revisions back to the years of original discovery is shown in Fig. 5. The all-time peak discovery year was 1930, when the East Texas field was found. Although this field had originally been estimated to be capable of providing 2,000,000,000 bbl. of oil, subsequent extensions and revisions in estimates have built the ultimate reserve figure of that field up to more than 5,000,000,000 bbl. Much of the quantities credited back in Fig. 4 were credited to the year 1930, with the result that reserves credited to that year reached the stupendous figure of 6,000,000,000 bbl. The depth of the depression in 1932 brought a severe decline in exploratory drilling and reduced the quantity of reserves discovered in that year to only 400,000,000 bbl., the lowest figure in 16 years.

The secondary peak of reserve discoveries since 1930 was 1937, when the industry discovered 2,529,000,000 bbl. of new oil supply. Since then there has been

FIG. 3. RESERVES DISCOVERED AND EXPENDITURES

The sharp decline in new discoveries through new fields and extensions to previously found fields has been accompanied by materially increased cost of exploratory operations. Last year it took 5.63 exploratory wells to find one million barrels; in 1936 it was 1.53. During this period expenditures per well increased nearly 100 per cent.



a sharp downward trend in reserve discoveries. Meanwhile, the trend of crude oil production, particularly since the outbreak of war, has been sharply upward. Since 1937, the annual output of crude oil in the United States has shown an increase of 401,000,000 bbl.

Table 5 crystalizes the effect upon reserve inventories by allocating back extensions to previously discovered fields and revisions of former estimates. Reported reserves at the beginning of 1935 were 12,177,000,000 bbl. Total discoveries between 1935 and 1944, including extensions and revisions, amounted to 21,641,000,000 bbl. This amount added to the opening inventory and subtracting the cumulative production of 13,179,000,000 bbl. leaves 20,639,000,000 bbl. at the close of 1944. By allocating back all extensions and revisions to original discovery years, the opening inventory, January 1, 1935, was adjusted to 19,189,000,000 bbl. The total discoveries credited to each year since 1935 are shown to be 14,808,000,000 bbl. and production is the same as in the first calculation. The remaining reserves at the close of 1944 amounted to 20,818,000,000 bbl. The peak reserve inventory of 23,945,000,000 bbl. at the beginning of 1940 compares with reported reserves at that time of 18,483,000,000 bbl., or a difference of 5,462,000,000 bbl. This differ-

TABLE 5

U. S. crude petroleum reserves situation.

Showing underground inventories, discoveries and allocations (millions of barrels)

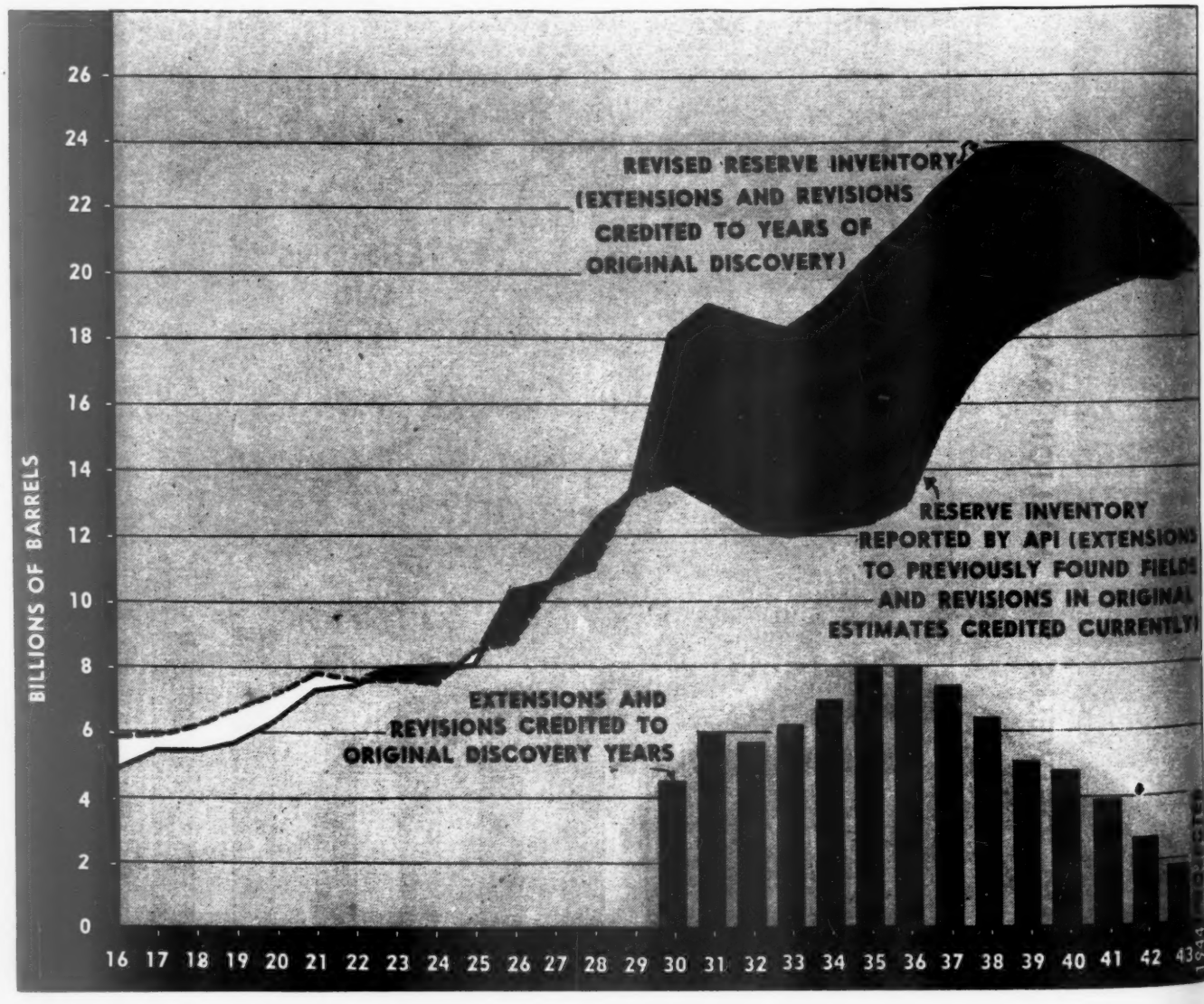
Year	Reported Reserves Jan. 1	Total added to reserves	Annual production	New field discoveries	Allocation of extensions and revisions	Adjusted reserve inventory
1935	12,177	1,220	997	950	1,350	19,189
1936	12,400	1,763	1,100	850	1,350	20,492
1937	13,063	3,723	1,279	929	1,600	21,492
1938	15,507	3,055	1,213	810	1,370	22,742
1939	17,348	2,400	1,265	341	1,160	23,709
1940	18,483	1,895	1,353	286	950	23,945
1941	19,025	1,967	1,402	430	585	23,828
1942	19,590	1,880	1,387	260	405	23,441
1943	20,083	1,485	1,503	282	370	22,719
1944 (p)	20,064	2,253	1,680	235	395	21,868
1945 (p)	20,639					20,818

	Method 1(a)	Method 2(b)
Opening inventory	12,177,000,000	19,189,000,000
Added to reserves	21,641,000,000	14,808,000,000
Total	33,818,000,000	33,997,000,000
Production	13,179,000,000	13,179,000,000
Closing reserves	20,639,000,000	20,818,000,000

(p) Preliminary.
(a) Crediting all discoveries currently.
(b) Crediting extensions and revisions to original discovery years.

FIG. 4. CRUDE OIL RESERVE INVENTORIES.

When extensions and revisions are credited to original discovery years, as was done in compiling the revised reserve inventory, it is obvious that the peak of reserves was reached in 1939. Since then the underground inventory of proved reserves has declined 3,100,000,000 barrels.


BILLIONS OF BARRELS
26
24
22
20
18
16
14
12
10
8
6
4
2
0
REVISED RESERVE INVENTORY (EXTENSIONS AND REVISIONS CREDITED TO YEARS OF ORIGINAL DISCOVERY)
RESERVE INVENTORY REPORTED BY API (EXTENSIONS TO PREVIOUSLY FOUND FIELDS AND REVISIONS IN ORIGINAL ESTIMATES CREDITED CURRENTLY)
EXTENSIONS AND REVISIONS CREDITED TO ORIGINAL DISCOVERY YEARS
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
1944 PROJECTED

ence represents the amount of subsequent extensions and revisions that were credited back to original discovery years.

Fig. 6 relates the industry's exploratory effort with the quantity of new reserves found per dry hole drilled. The curve of discoveries per dry hole in Fig. 5 shows a decidedly close conformity with total reserve discoveries credited to each year. It is significant that the trend of exploratory drilling, as measured by the number of dry holes, has been upward since 1933, but the quantity of new reserves found per dry hole drilled has shown a steady downward trend since 1935. Likewise, the number of wildcat wells drilled since 1937 has shown a steady increase to a new peak in 1944 of nearly 3800 and yet the rate of new reserve discoveries has shown no reversal in the downward trend.

The period of greatest reserve discovery, 1926-30, was marked by the drilling of 36,901 dry holes, the greatest number in the industry's history. During that period the quantity of new oil found per dry hole drilled was 396,000 bbl., whereas the peak year of 1930 showed an average per dry hole drilled of 891,000 bbl. By comparison it is seen that in the last four years the industry drilled 25,835 dry holes and the average rate of discovery per dry hole was only 115,000 bbl. In 1944, which provides for subsequent extensions and revisions to initial discoveries, the finding rate per dry hole drilled was only 88,000 bbl. This was the smallest discovery rate since 1918.

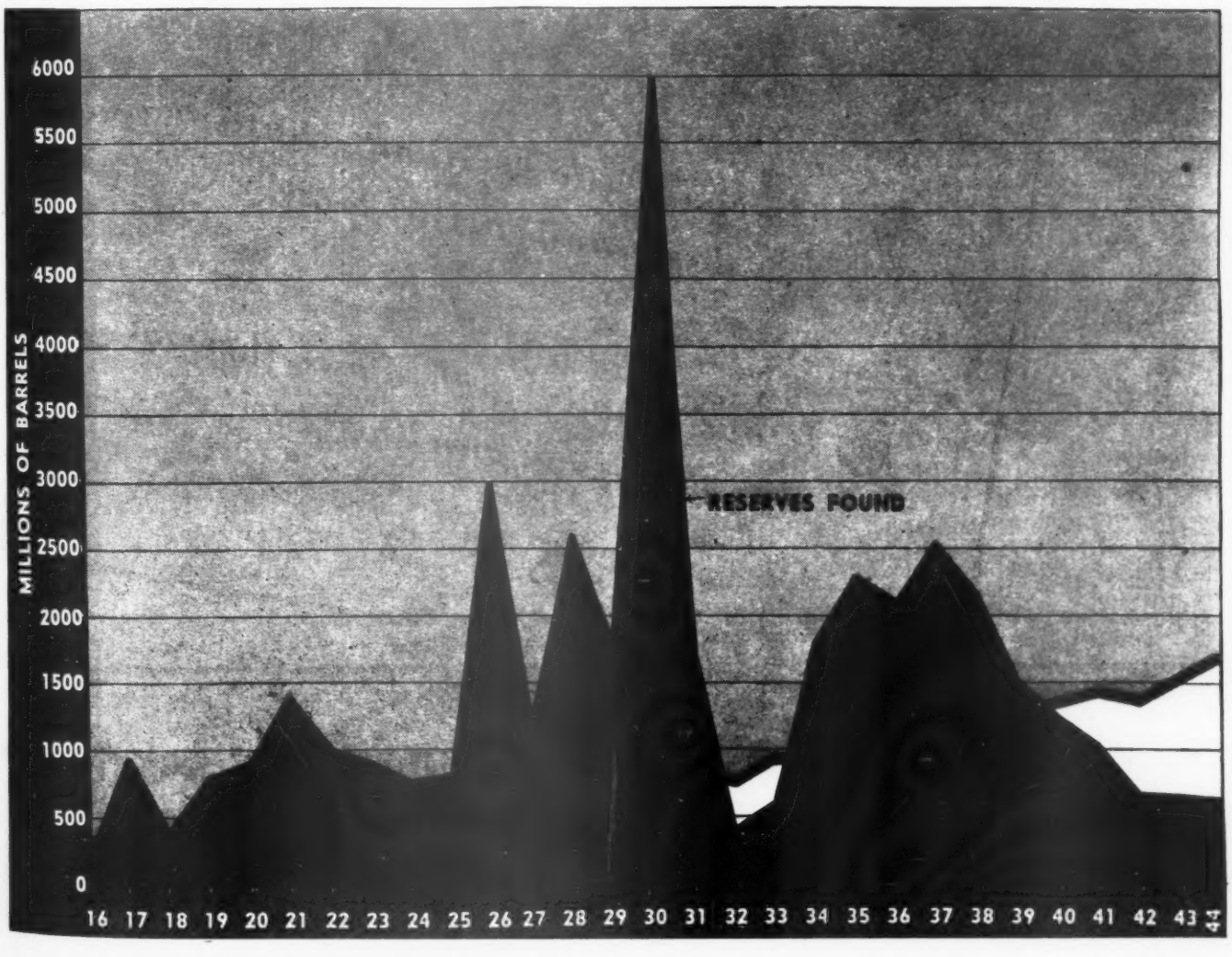
Despite the fact that the American oil industry's ability to find new, needed reserves has been seriously impaired during the last eight years, there is little reason to view the future with great alarm. Discussion of the nation's oil finding prospects with eminent authorities on that subject provides the assurance that many billions of barrels of yet unproved oil supply may be found in the future. Of particular concern at this time, however, is the fact that new field discoveries are considerably smaller than in previous years and the cost of exploration is multiplying by leaps and bounds. Conservative estimates indicate that the American oil industry may yet find far more oil than is now known to be our proved reserve inventory. The difficulty is that it is harder to find and far more costly to find than ever before in the history of the oil industry.

All told, the oil industry has discovered since 1859 the stupendous quantity of 50,595,366,000 bbl. of crude oil and has produced from its known reserves a total of 29,777,366,000 bbl. This leaves a remaining proved reserve of 20,818,000,000 bbl. With new oil reserves being found in the southeastern states as well as in many of the older producing states, it is authoritatively estimated that the ultimate oil supply of the United States is in the neighborhood of 80,000,000,000 bbl. This does not include present or prospective reserves of natural gas, which are an important adjunct to the nation's proved and prospective oil reserves. As the total proved and produced supply of crude to date has been more than 50,000,000,000 bbl., it is apparent that the industry may yet find and develop at least 30,000,000,000 bbl. of prospective oil supply for future needs.

A factor of far-reaching importance to the oil supply situation is the reserve picture of the United States in relationship to that of the rest of the world. Against our present known reserves of 20,000,000,000 bbl., the rest of the world is estimated to have about 45,000,000,000 bbl. Although this is over twice as much as our known supply the startling fact is that our supply as measured by our present rate of production represents 12 years, whereas that of the rest of the world represents about 48 years, at the

FIG. 5. PROVED RESERVES DISCOVERED AND CRUDE PRODUCED.

By crediting back all extensions and revisions to years of original discovery, it is apparent that the trend of new oil found has been downward since 1937.



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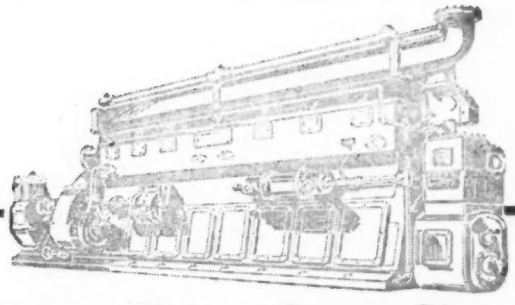


Corporation Mount Vernon, Ohio — Grove City, Pa.

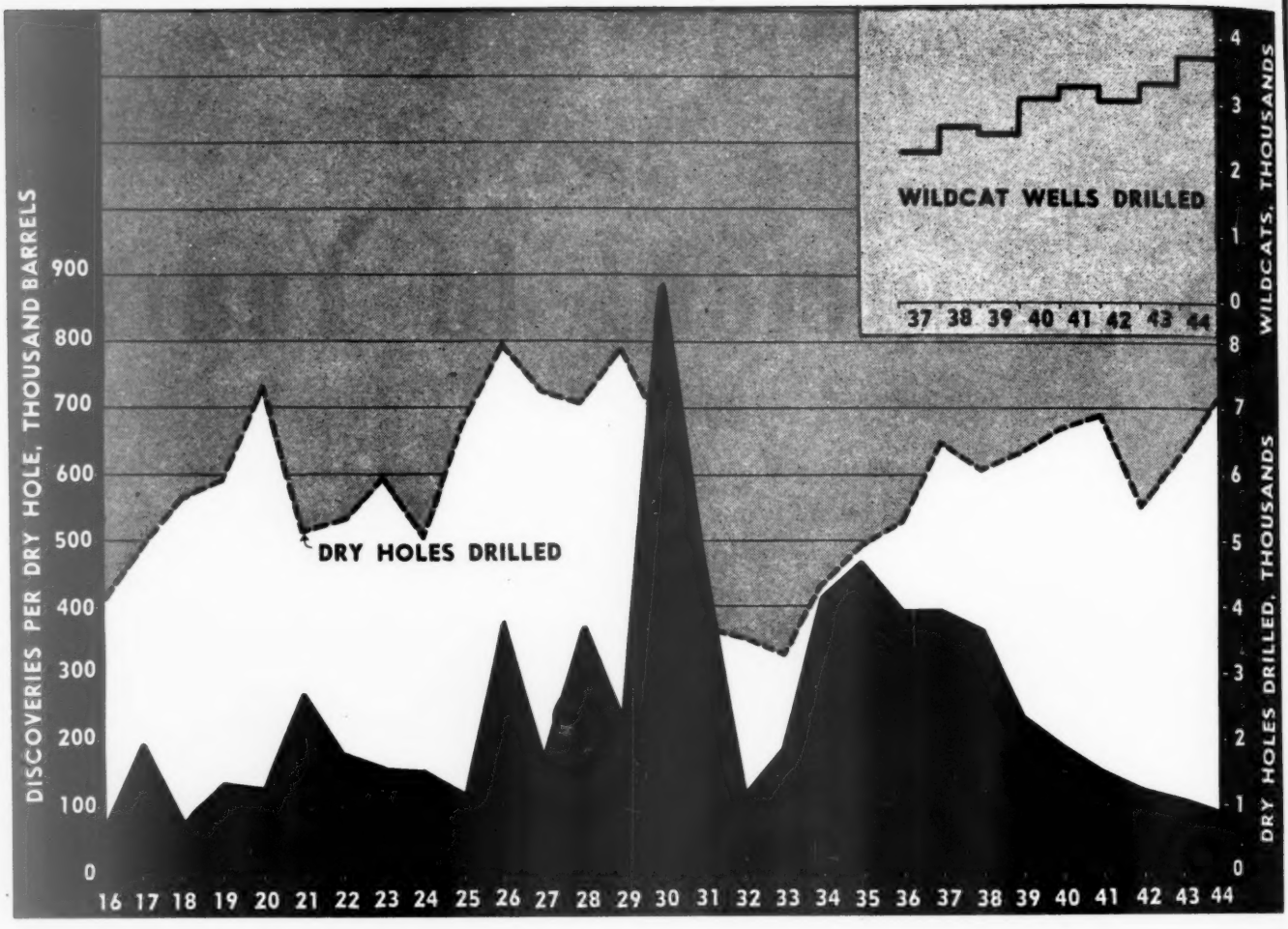


FIG. 6. DRY HOLES DRILLED AND NEW RESERVES DISCOVERED. Despite the fact that dry holes drilled (which are a reliable index of exploratory effort) have approached the peaks of 1926 and 1929, the quantity of new reserves discovered per dry hole has declined 81 per cent since 1935. Meanwhile, wildcat operations have been increased 70 per cent.

current consumption rate for the rest of the world. The United States has 31 per cent of the world's proved reserves of oil and is producing 64 per cent. The rest of the world has 69 per cent of the reserves and produces 36 per cent. The rate at which we have consumed our reserves, in relationship to that of the rest of the world, presents a not too comforting future outlook for the United States. Yet, if economic conditions permit the American oil industry to continue its search for new sources of supply, it may be possible for us to avoid or at least delay dependence upon the rest of the world for our petroleum requirements.

When we view the reserve picture outside the United States and the economic conditions under which other nations exist it is evident that one of the industry's main future difficulties will be the competitive outlook for world markets and the maintenance of price levels necessary to the continued welfare of the American petroleum industry. ★★★

TABLE 4—Dry holes, reserves, production.

Year	Dry holes drilled	Reserves discovered* (million bbl.)	Discoveries per dry hole (bbl.)	Annual production†	Adjusted reserve inventory†	Reported reserve inventory†
1916	4,039	250	62,000	301	4,868	5,900
1917	4,851	950	196,000	335	5,483	6,900
1918	5,613	400	71,000	356	5,527	6,200
1919	5,986	800	134,000	378	5,949	6,700
1920	7,364	900	122,000	443	6,406	7,200
5 yr.	27,853	3,300	118,000	1,813		
1921	5,160	1,400	271,000	472	7,334	7,800
1922	5,332	1,000	187,000	557	7,777	7,600
1923	5,883	900	153,000	732	7,945	7,600
1924	5,044	750	149,000	714	7,981	7,500
1925	6,734	800	119,000	764	8,017	8,500
5 yr.	28,153	4,850	172,000	3,239		
1926	7,965	3,000	377,000	771	10,246	8,800
1927	7,210	1,200	166,000	901	10,545	10,500
1928	7,078	2,600	367,000	901	12,244	11,000
1929	7,914	1,800	227,000	1,007	13,037	13,200
1930	6,734	6,000	891,000	898	18,139	13,600
5 yr.	36,901	14,600	396,000	4,478		
1931	3,659	1,700	465,000	851	18,988	13,000
1932	3,569	400	112,000	785	18,603	12,300
1933	3,312	600	181,000	906	18,297	12,000
1934	4,312	1,800	417,000	908	19,189	12,177
1935	4,911	2,300	468,000	997	20,492	12,400
5 yr.	19,763	6,800	344,000	4,447		
1936	5,296	2,100	396,000	1,100	21,492	13,063
1937	6,420	2,529	394,000	1,279	22,742	15,507
1938	6,043	2,180	361,000	1,213	23,709	17,348
1939	6,357	1,501	236,000	1,265	23,945	18,483
1940	6,617	1,236	187,000	1,353	23,828	19,025
5 yr.	30,733	9,546	311,000	6,210		
1941	6,885	1,015	147,000	1,402	23,441	19,590
1942	5,532	665	120,000	1,387	22,719	20,083
1943	6,266	652	104,000	1,503	21,868	20,064
1944 (p)	7,152	630 (r)	88,000	1,680	20,818	20,639
4 yr.	25,835	2,962	115,000	5,972		

*Extensions and revisions credited to discovery years.
(r) Projected to include subsequent extensions and revisions.
(p) Preliminary estimates.
†Million bbl.

METHODS OF CALCULATING EFFECT OF SHUTDOWN DAYS

By **K. MARSHALL FAGIN**, *Field Editor*

EXCLUSIVE CONSIDERABLE misunderstanding and confusion often occurs when oil men speak or write of the "daily allowable" of a well or field in the State of Texas on account of the general application of "shutdown" days to the basic allowable as it is printed on the proration schedule. The Railroad Commission of Texas has used the shutdown order each month since December 1937 as a successful device to regulate the production from Texas fields to meet the demand or the maximum efficient production rate without having to recalculate basic individual well allowables and issue complete new proration schedules each month.

K. M. Fagin

Currently, the statewide shutdown order closes down most fields a certain number of days each month, or requires that production be reduced an equivalent amount in cases where operators do not wish to shut in their wells. Some fields and certain wells are always exempted from this regular monthly order, because of unusual operating conditions such as heavy water production, vacuum, etc., and a large number of fields are ordered to shut down a special number of days, sometimes more and sometimes less than the number of "statewide" days.

This problem of understanding the effect of these shutdown days on the basic allowables can be mitigated by carefully qualifying the terms. If someone asks, "What was the daily allowable of our Jones No. 1 in the East Texas field for December, 1944?" the reply might correctly be, "The *scheduled* allowable was 20 bbl. per day, but the well was either shutdown 7 days during the month or produced at the rate of 15.5 bbl. per day, on account of the shutdown order." If the answer was simply, "Twenty barrels daily," the person might not have realized the shutdown order would cut the daily average production of the well to 15.5 bbl. per calendar day for the month.

Those who deal with this subject every day understand each other without much difficulty and have developed their own ways of calculating the effect of the shutdown orders on the scheduled allowables. One of the biggest problems is adequately to inform those who are not so conversant with these matters.

Charts for rapid calculation. One way for quickly translating basic or scheduled allowables into average daily allowables or production for a given month is by the construction of large charts similar to Fig. 1, which is for a 30-day month. With a chart like this for a 31-day month, one for a 28-day month, and a good straight edge (preferably transparent), the scheduled daily allowable of a number of wells can be rapidly converted to the average daily allowable or production for any given month. A set of these charts should be especially useful to field production clerks, foremen, engineers, and superintendents in advising lease men the total and average daily production to make from their wells, or in calculating the net effect of changes in allowable and number of shutdowns from one month to another.

Method of chart construction: (a) For months with 30 days—Select a liberal-sized piece of cross-section paper. Lay off the *basic allowable scale* from 0 on the lower left to any desirable figure on the right such as 40, 60, 80, or 100, depending on the range of basic well allowables in the particular district. Next, mark off the same scale along the right side of the chart from 0 on the base line to the highest figure on the top. Then, label the scales as in Fig. 1. Next, mark the points where the vertical 30-bbl. line crosses the horizontal 30, 29, 28, 27..... lines. Now, draw the diagonal lines from 0 on the lower left through these points. As can be noted, the lines are alternately plain and dashed. This improves the ease of using the chart and tends to eliminate errors. In some cases, it might be better to use different colors on the diagonal lines to facilitate distinction in use.

Next, label the diagonal lines and make the *total production scale* on the left side of the chart as shown.

(b) For months with 31 days: Lay off and label the *basic allowable* and *average daily allowable scales* as for the 30-day month chart. Next, mark the points where the vertical 31-bbl. line crosses the horizontal 31, 30, 29, 28, 27,.... lines. Now, draw the diagonals as explained before. As can be noted, the 0 shutdown day diagonal is the same one as on the 30-day month chart, but the 1, 2, 3, 4, 5,.... lines are progressively a little higher than on the first chart. Next, mark off the total production scale on the left-hand side of the chart. This scale for a 31-day month will be in multiples of 31, so that 310 will be opposite 10 instead of 300, 620 will be opposite 20, 930 will be opposite 30, etc.

(c) For months with 28 days: Measure off and label the *basic allowable* and *average daily allowable* scales as for the previous charts. Next, mark the points where the vertical 28-bbl. line crosses the horizontal 28, 27, 26, 25,.... lines. Now, draw the diagonals as explained before. Here, as on the other two charts, the 0 shutdown day diagonal is the same, but the 1, 2, 3, 4, 5,.... lines are progressively a little lower than on the others. Next, lay off the total production scale on the left side of the chart. This scale for a 28-day month will be in mul-

TABLE 1

Factors for converting from basic or scheduled allowable to average per calendar day.

No. of producing days	For 31-day months No. shutdown days	Decimal	For 30-day months No. shutdown days	Decimal	For 28-day months No. shutdown days	Decimal
31	0	1.0000				
30	1	0.9677	0	1.0000		
29	2	0.9355	1	0.9667		
28	3	0.9032	2	0.9333	0	1.0000
27	4	0.8709	3	0.9000	1	0.9643
26	5	0.8387	4	0.8667	2	0.9286
25	6	0.8065	5	0.8333	3	0.8929
24	7	0.7742	6	0.8000	4	0.8571
23	8	0.7419	7	0.7667	5	0.8214
22	9	0.7096	8	0.7333	6	0.7857
21	10	0.6774	9	0.7000	7	0.7500
20	11	0.6452	10	0.6667	8	0.7143
19	12	0.6129	11	0.6333	9	0.6786
18	13	0.5806	12	0.6000	10	0.6429
17	14	0.5484	13	0.5667	11	0.6071
16	15	0.5161	14	0.5333	12	0.5714
15	16	0.4839	15	0.5000	13	0.5357
14	17	0.4516	16	0.4667	14	0.5000
13	18	0.4194	17	0.4333	15	0.4643
12	19	0.3871	18	0.4000	16	0.4286
11	20	0.3548	19	0.3667	17	0.3929
10	21	0.3226	20	0.3333	18	0.3571
9	22	0.2903	21	0.3000	19	0.3214
8	23	0.2581	22	0.2667	20	0.2857
7	24	0.2258	23	0.2333	21	0.2500
6	25	0.1935	24	0.2000	22	0.2143
5	26	0.1613	25	0.1667	23	0.1786
4	27	0.1290	26	0.1333	24	0.1429
3	28	0.0968	27	0.1000	25	0.1071
2	29	0.0645	28	0.0667	26	0.0714
1	30	0.0323	29	0.0333	27	0.0357

tiples of 28. Thus, 280 will be opposite 10 instead of 300, 560 will be opposite 20, etc.

Examples of chart use: To illustrate the method of using the charts, Fig. 1 is marked with two dashed lines and the letters A, B, C, and D, for the case where a well is allowed 20 bbl. per producing day, but is shut down 6 days out of the 30-day month. A straight edge is simply moved horizontally upward from point A to point B where the vertical 20-bbl. line crosses the diagonal 6 shutdown day line. The average daily allowable is found on the right hand scale at point C, which is 16 bbl. The *total production* for the month from this well is found at point D on the left hand scale, which is 480 bbl. in this case.

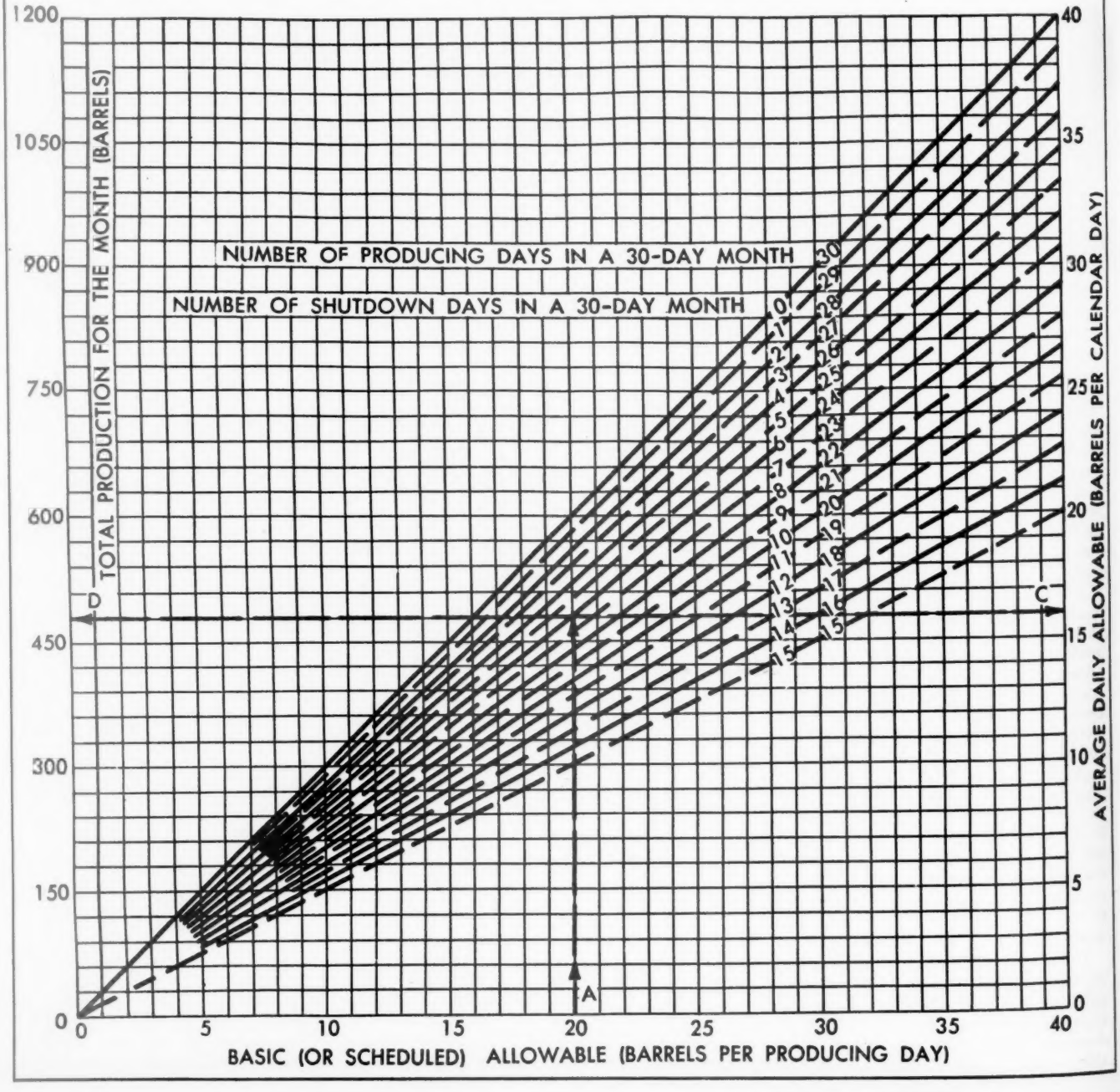
The accuracy of the charts is naturally limited by their size and denominations, as well as by the accuracy of their preparation and the care exercised by the calculator. However, they can easily be made accurate enough for many useful purposes where calculating machines are not available and time is limited.

Another and perhaps more general use for the charts would be the calculation of average daily allowable from the total monthly allowable, which is given operators in Kansas and some other states. In this procedure, the diagonal lines would be ignored. The chart reader would simply place his straight-edge on the total month's allowable figure on the left-hand scale and read the average daily allowable on the right-hand scale. In other states, these charts might prove useful by reversing this procedure to find the total month's allowable from the daily allowable as received on the proration schedules.

Other methods. Table 1 lists factors that can be multiplied by a basic allowable to obtain the average daily allowable for a given month. For example, a well is allowed 25 bbl. per day, according to the schedule, but is required to shut down 5 days out of a 31-day month. Looking down the 31-day month column opposite the number 5 (number of shutdown days given), is the decimal 0.8387, which is multiplied by 25 to obtain the average daily production of the well. The answer is 20.9675, or practically 21 bbl. per calendar day.

Use of the factors given in this table either by longhand or machine multipication should save considerable time in the conversion of scheduled allowable to the average per calendar day whenever the scheduled allowable is subject to shutdown days. ★★★

FIG. 1. AVERAGE DAILY ALLOWABLE AND TOTAL PRODUCTION CHART FOR A 30-DAY MONTH



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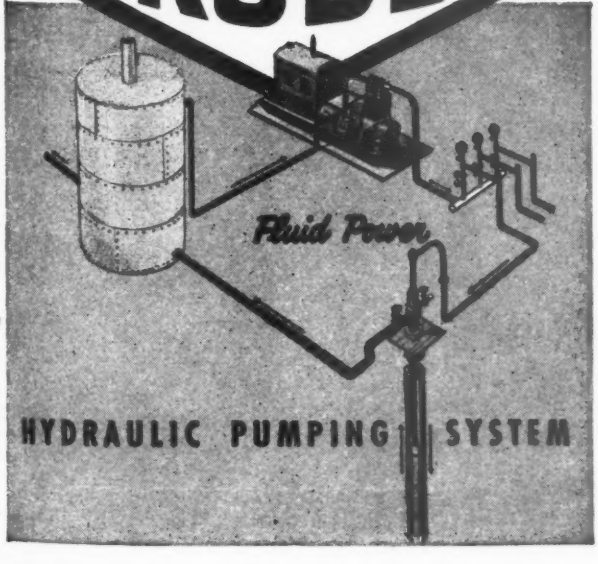

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ENGINEERING ASPECTS OF UTAH 100-OCTANE PLANT

By **JOHN H. KUNKEL,** Refinery Editor

PART 2

EXCLUSIVE **Alkylation and butane isomerization unit.** The feed to the sulphuric acid catalytic alklation unit is as follows:

(a) The total B-B fraction from Plant No. 2 intermediate storage. This intermediate storage B-B is composed of refinery B-B from Plant No. 1, which is fed to the gas recovery unit debutanizer plus the C_5s obtained from the gas recovery unit, the total of these going to storage as overhead from the debutanizer. In addition, the B-B intermediate storage receives C_4 and lighter as overhead from the naphtha isomerization feed preparation unit debutanizer.

(b) Caustic-washed propane - propene, overhead from the gas recovery unit depropanizer.

(c) The C_5 through 150° F. end point fraction (pentene plus a small quantity of hexenes) from its intermediate storage, this fraction being the overhead from the gas recovery unit rerun tower No. 1.

On the vapor phase butane isomerization side, the feed is n-butane plus a small amount of isobutane and traces of isopentane from the alkylation unit debutanizer overhead.

The alkylation plant reaction section contains 4 reactors. Three of these form the section's butene alkylation unit; the fourth forms its pentene alkylation unit. Feed to the butene unit is B-B and C_5s (items "a" and "b" listed above), whereas feed to the pentene unit is pentene and hexene ("c" as above).

Feed to the reactors (the butene unit reactors and the pentene unit reactor are fed through separate lines) enters and combines with a stream of recycle isobutane — bottoms from the alkylation unit depropanizer. These are cooled by exchange against the reactor effluent and enter the reactors to mix with the catalyst —sulphuric acid—forming the emulsion in which the reaction takes place. Effluent from the butene and pentene reactors meet in a common line, cool the incoming feed bypassing through the previously mentioned exchanger, and go to the caustic-wash settler.

▸ **Reactors.** The reactors are horizontal vessels (Fig. 1). Each reactor is divided into 3 sections, upright weirs forming the partitions. These sections are: Reaction; settling, in which spent acid settles out and is withdrawn from the reactor's bottom, and a hydrocarbon effluent section.

The feed line entering the reactor extends into and across the bottom of the reaction section, this inside portion of the line being studded with high velocity glass jets at an angle of 35-40 deg.

The feed to the butene reactors from the exchangers meets a stream of recycle emulsion, the composition of which is 50 per cent sulphuric acid and 50 per cent hydrocarbon, and the combined feed and emulsion enter each reactor's reaction section; the rapid circulation of the emulsion plus the high-velocity glass jets supplying the vigorous agitation required. Residence time in the reaction section is approximately 30 min.

In the settling section spent acid, settling out of the emulsion, is withdrawn from the base. Normally, this spent acid is pumped to the pentene reactor where it is introduced into the pentene feed line. However, spent acid can be recirculated back to the butene unit feed line.

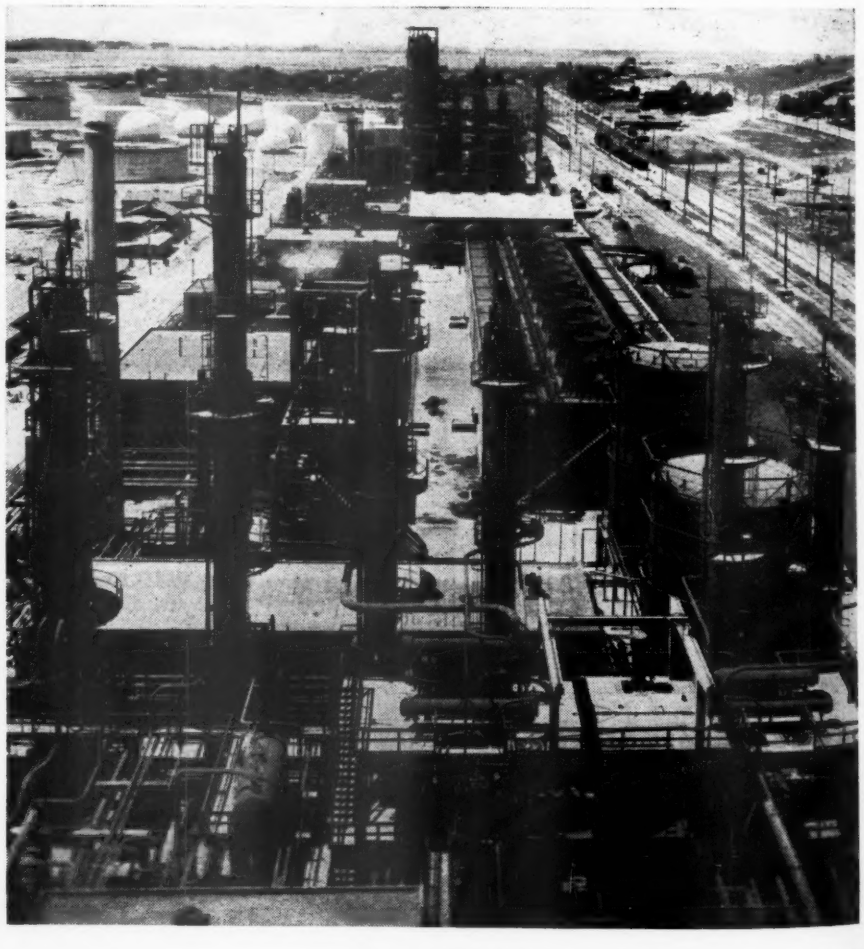
The reaction heat is dissipated by an automatic refrigeration cycle. An overhead vapor line, positioned over the settling section, conveys hot vapor to a knockout drum for removal of any liquid before compression. Hot vapor, from the compressor discharge, is passed through a water-cooled condenser, which liberates the heat. Cool liquid from the condenser goes to a surge drum and then returns to the reactor, entering it above the feed line in the reaction section.

Hydrocarbon effluent in the third section of the reactor is pumped to the caustic wash drum for preparation as feed to the alkylate fractionator unit.

In the reactors the olefin molecule and the isobutane molecule are combined to form predominantly: Isoheptanes in the case of C_5s; isooctanes in the case of C_6s; isononanes in the case of C_7s; isodecanes in case of C_8s; the net result being aviation alkylate.

Effluent from the reactors goes to the caustic-wash drum for the removal of any traces of acid and then to a water-wash drum for removal of any caustic after which it passes through a low pressure 10-lb. steam preheater using exhaust steam from the refinery's pumps and compressors for preheating to 154° F., and then to the alkylation plant's deisobutanizer.

▸ **Alkylate fractionation.** The alkylation plant's fractionation section contains the following principal columns:



View of vapor recovery unit with hydrogen plant in background. Vapor recovery unit towers, foreground, left to right: Lean oil still, absorber, rerun No. 2, depropanizer debutanizer, and rerun No. 1. In the right foreground, hydrogen unit inert gas holders.

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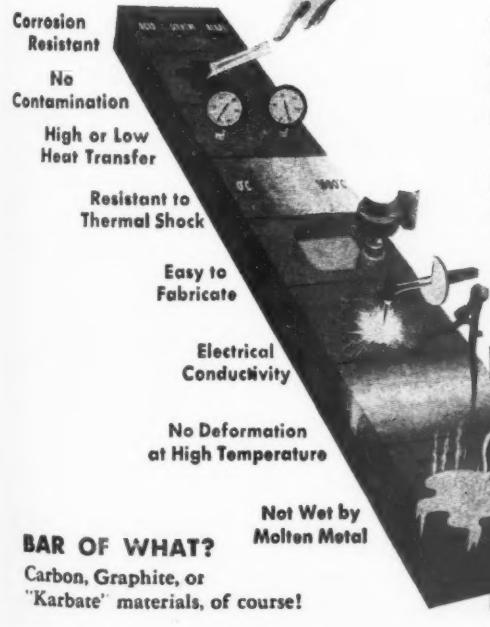

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CATALYTIC ALKYLATION AND BUTANE ISOMERIZATION UNIT

Utah Oil Refining Company

essed by incorporation of a moderate amount of corrosion-resistant materials in the reactor. *Tomorrow*... this flexibility will permit use of the most economical of feeds to produce premium postwar products.

3. Control of product quality is simplicity itself. Due to the fluid properties of the catalyst... its flow responds to recognized principles. Operating conditions for any run can be quickly established and maintained with little, if any, adjustment of a few simple controls.

4. The flow principle of the catalyst system requires no moving mechanical parts, thus assuring a high service factor. On-stream runs of 4 to 6 months have been reported to date. In addition to this saving in operating time... conventional maintenance costs are reduced to a minimum.

Small additions of catalyst which are easily and regularly injected into the system maintain the catalyst at high efficiency. Manpower costs for operation and maintenance are also minimized.

QUESTION 3: What has M. W. Kellogg contributed to catalytic-cracking?

ANSWER:

On the record... *over two-thirds* of the *Fluid* "Cat-Cracking" capacity built since Pearl Harbor—and now in operation—has been built by The M. W. Kellogg Company. Our laboratory helped develop the *Fluid* technique ... our engineers translated it into commercial reality. Today, our continuous pilot-plant operation provides the accurate data necessary to evaluate feed stocks and to evolve process designs for specific applications.

CONCLUSION

production of high-oc
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and pilot-plant operati
and construction...Th

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TRUE TODAY!
It's Fluid 2 to 1

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★Only Kellogg Service Has Them All

★ **LABORATORIES**—fully equipped and staffed—devoted exclusively to chemical engineering and process development.

★ **24-HOUR-A-DAY PILOT PLANTS**—17 refining processes operating continuously—providing accurate data for commercial scale application.

★ **EXCLUSIVE CHEMICAL ENGINEERING DATA**—Continuously compiled... embracing both pilot plant runs and the operation of Kellogg-built refineries. Data extends from beginning of modern refining.

★ **PROCESS ENGINEERS**—Specialists who have continuously made major contributions to oil refining development, for more than 20 years... currently exemplified by their work on fluid catalytic-cracking.

★ **MECHANICAL ENGINEERS**—Kellogg installations—worth hundreds of millions—are their best reference.

★ **METALLURGICAL LABORATORY**—Establishes continuous check of specifications...creates new techniques for the fabrication of refining equipment.

★ **PERMANENT CONSTRUCTION CREWS**—Geared to function all over the world on single units or multiphase refineries... team-experience cuts costs, speeds construction.

★ **OPERATING STAFFS**—Specialists at placing new units "on stream"... training of refiner's own operating crews.

★ **LICENSING SERVICE**—Licenses available through Kellogg as sponsor or licensing agent for all types of refining.

ECONOMICS CONSULTATION—Offers oil companies the opportunity to have their overall operations reviewed and evaluated by personnel with authoritative and extended experience in the field of petroleum economics and management.

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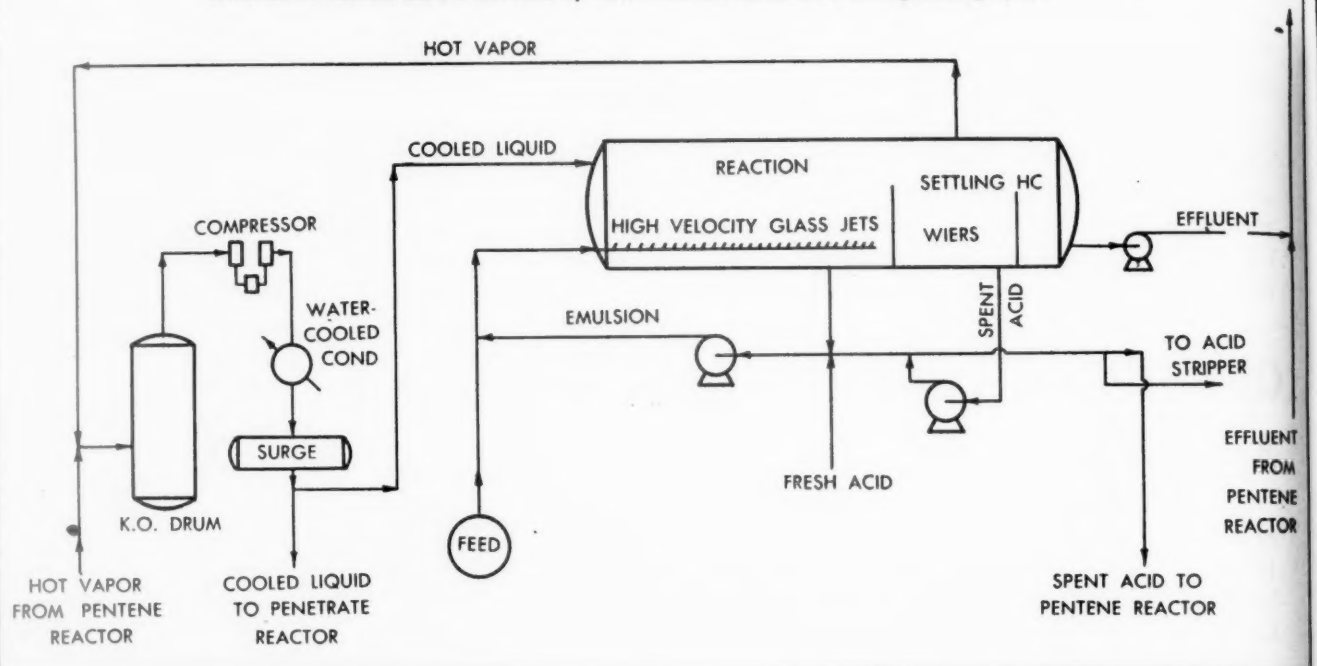
FIG. 1. Simplified diagram of No. 2 butene reactor illustrating flow of feed and acid, division of reactor into 3 sections by weirs and the automatic refrigerating cycle.



A 50-tray deisobutanizer, a 28-tray depropanizer, 24-tray debutanizer, and a 16-tray rerun column.

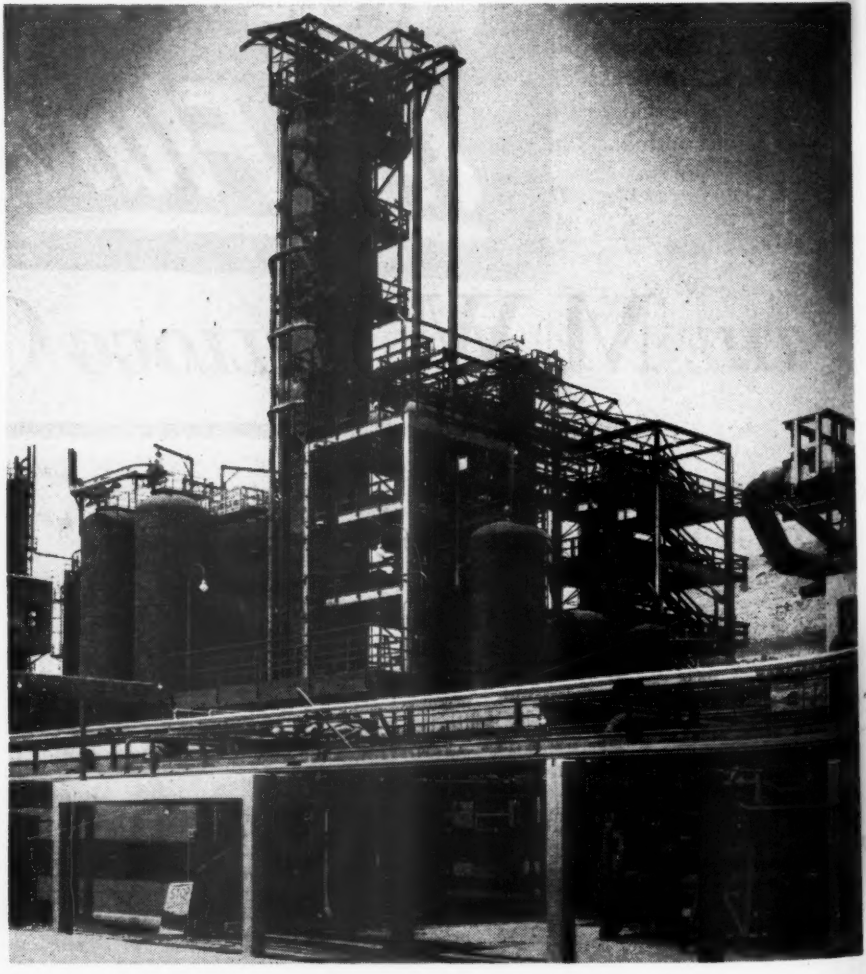
The deisobutanizer receives the preheated feed from the water-wash drum over its 12th, 18th, or 24th tray. The overhead of this column is iso-C_4 and C_3 plus some n-butane, which passes through a condenser to a reflux drum. Reflux is drawn from the base of the drum and pumped back over the column's top tray. The overhead from the reflux drum passes through an overhead product cooler to an accumulator from which the depropanizer is fed. Bottoms are n-butane and alkylate with some iso C_4. The column is equipped with 2 low pressure 10-lb. steam reboilers each designed for a duty of 33,000,000 B.t.u. per hr. The deisobutanizer is designed for a pressure of 120 lb. Its temperatures are: Bottom, 201° F.; top, 136° F.

The feed to the depropanizer is preheated to 156° F. by passing through a low pressure 10-lb. steam preheater before entering the tower at the 15th, 19th, or 23rd tray. This column is designed for a pressure of 258 lb. Its temperatures are: Bottom, 194° F.; top, 121° F.

The depropanizer overhead is C_3, which passes through an overhead condenser to a reflux drum. Reflux from the bottom of the drum is pumped back over the column's top tray, the drum overhead vapors going to plant fuel. Bottoms, isobutane with traces of C_3 and n-C_4, go through a bottoms cooler and are recycled to meet the alkylation plant's fresh feed to the reactors. A low pressure 10-lb. steam reboiler designed for a duty of 10,400,000 B.t.u. per hr. serves the column.

Bottoms from the deisobutanizer form the feed to the debutanizer, entering over the 13th or 17th tray. The design pressure of this column is 100 lb. Its temperatures are: Bottom, 300° F.; top, 146° F.

C_4 and a small amount of iso-C_4 and iso-C_5 as feed for the butane isomerization unit is the overhead from the debutanizer. The overhead is condensed and accumulated in a reflux drum. The



Alkylation unit fractionating section. Left to right: Deisobutanizer at extreme left, reflux drums on main pump house roof, and small vertical nC_4 and isoC_4 surge storage tanks.

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★ So great has been the interest of the petroleum industry in the new Sterling Viking Diesel that we have already set up production line methods of manufacturing this advanced streamlined engine. This means we can accept orders now for early delivery of this modern improved power plant for operating drilling rigs, slush pumps, booster pumps, electric generator sets, and many other continuous or stand-by power applications. Sterling engineers will gladly cooperate in planning installations of the Sterling Viking Diesel best suited to your particular requirements—six or eight cylinder; supercharged or unsupercharged. Write for illustrated engineering bulletins.

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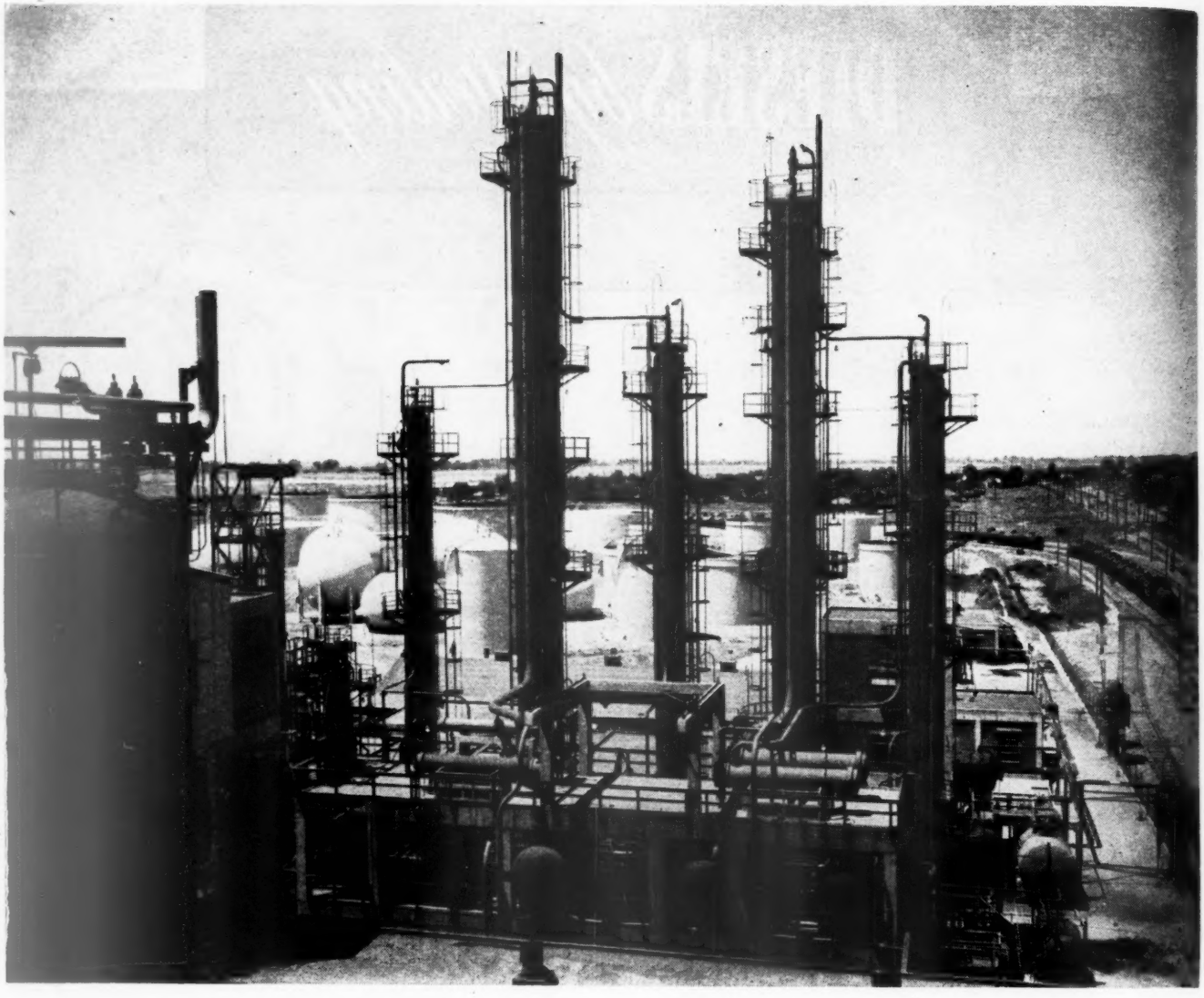


Naphtha isomerization unit fractionating towers. Left to right: Naphtha debutanizer, naphtha pentanizer, heptane tower, neohexane tower, and isomate debutanizer.

line from the drum splits, sending a portion of the product back over the top tray of the column, the balance going to the butane isomerization unit. Bottoms, pentane and alkylate, form feed to the rerun column. The debutanizer is served by a high pressure 240-lb. steam reboiler designed for a duty of 12,740,000 B.t.u. per hr.

The rerun column is designed for a pressure of 36 lb. Its temperatures are: Bottom, 365° F.; top, 215° F.

Feed enters the rerun tower over its 9th tray. The overhead is condensed and passed to a reflux drum. The stream from the drum is split, part refluxing the tower over its top tray while the balance is caustic-washed and goes to aviation alkylate storage. Bottoms, heavy alkylate, go through an aftercooler and then to motor gasoline storage.

Provision is made to introduce stripping steam into the bottom of the rerun tower. This assists in stripping out light ends in the heavy alkylate at lower temperatures than would be otherwise possible. The rerun tower is also equipped with a high pressure 240-lb. steam reboiler designed for a duty of 4,587,000 B.t.u. per hr.

▸ **Vapor phase butane isomerization.** The function of the vapor phase butane isomerization unit is to arrange molecules of n-butane to form molecules of isobutane by subjecting the n-butane to catalytic reaction.

The butane isomerization reactor system is arranged to provide maximum flexibility. Each of 2 reactor-feed vaporizers, 2 knockout drums, and 2 reactors may be used as separate units in parallel, or either vaporizer with its knockout drum may be used with either reactor.

Two $AlCl_3$ subliming pots are manifolded to supply $AlCl_3$ to either reactor. The equipment was designed for continuous or batchwise sublimation of $AlCl_3$ into the reactors, but all sublimations to date have been batchwise.

The 2 reactors may be used without a guard in parallel, or in series with the second reactor serving as a guard. The reactor effluent is sent to the HCl stripper and the stripper bottoms join the alkylation reactor effluent following the caustic mixers and enter the fractionation system. The overhead from the stripper joins the preheated reactor charge at the reactor inlet.

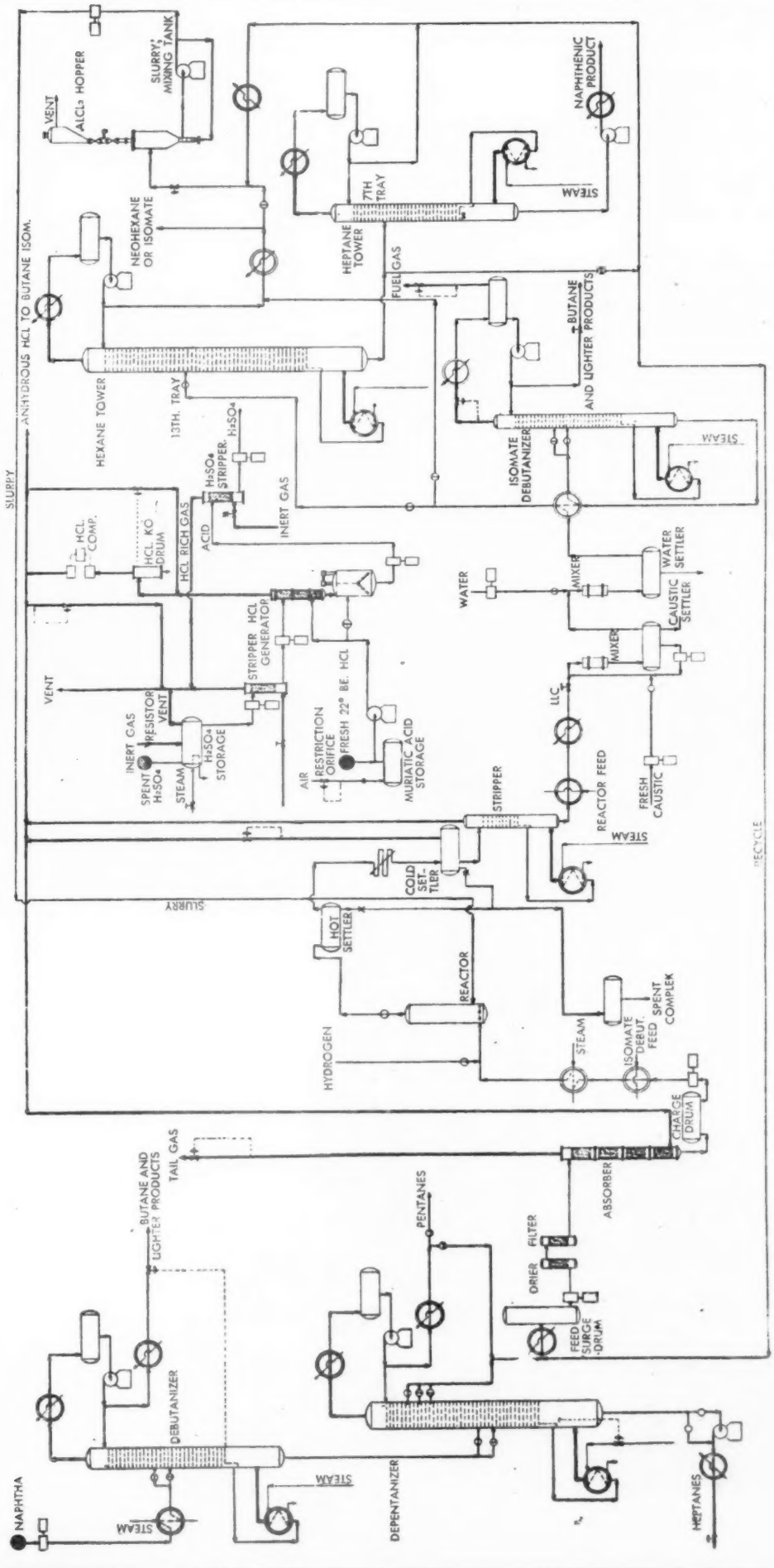
N-butane feed, containing a small amount of iso-C_4 and a trace of iso-C_5, is pumped through a calcium chloride drier to remove all traces of water and then through a sand filter to remove any calcium chloride fines carried over from the drier. After the drying operation, the feed passes through a high pressure steam preheater for vaporization. The vapors pass through a knockout drum for removal of any remaining liquid. During sublimation the vapors go to 2 aluminum chloride drums connected in parallel and finally to the isomerization reactors. During reaction time the vapors from the knockout drum bypass the aluminum chloride drums.

The charge to the isomerization reactors meets a stream of recycle HCl, plus makeup HCl when needed, at the reactor inlet. During sublimation the recycle HCl is bypassed around the reactor so that makeup $AlCl_3$ and HCl do not enter the reactor together.

The reactors are filled with a porous catalyst support on which the $AlCl_3$ is held. A mixture of C_4 hydrocarbons and HCl are fed from the reactors to the HCl stripper.

The HCl stripper is a 20-tray column designed for a pressure of 345 lb. Its

NAPHTHA FRACTIONATION AND ISOMERIZATION UNIT



Utah Oil Refining Company

temperatures are: Bottom, 215°F.; top, 105°F. The stripper's top product is HCl plus some C_3 and C_4, which is recycled back to the isomerization reactors. Isobutane, some n-C_4, with traces of C_5, and C_3 are bottoms. This material goes to the alkylation unit caustic wash drum where it is mixed with effluent from the alkylation reactors. The stripper is equipped with a steam reboiler designed for a duty of 2,840,000 B.t.u. per hr.

Naphtha isomerization. For the strategic reasons mentioned, the problem at Utah was that of obtaining the maximum 100-octane aviation gasoline make from the limited supply of locally available crudes, which are deficient in the higher quality volatility agents.

The crudes contain a substantial volume of hexanes, some components of which have a very low octane number as, for example, n-hexane, which has an ASTM octane number (clear) of 28. The crudes also contain n-pentane and some isopentane, the n-pentane having an ASTM octane number (clear) of 61. whereas the octane number (clear) of isopentane is 90. Thus, the process problem was that of converting the low octane value straight or slightly branched hyrocarbons to the more highly branched isomers of high octane number and, as a result, make them available as aviation gasoline components in high yield.

This process problem was solved at Utah by the new naphtha isomerization process developed by the Standard Oil Company of Indiana, and the process is responsible in a very large sense for the remarkably high 100-octane aviation gasoline make at that refinery.

The operation is especially suitable for processing light naphtha containing hexanes and pentanes, the end result being the production of a neohexane product in isopentane and isohexane, and particularly neohexane. The end product has an ASTM octane number (clear) of 83 to 94 depending on the C_5 and C_6 rates in the feed and the amount of recycling.

At Utah, the naphtha isomerization unit—or, as termed in the flow sheet, the neohexane unit—consists of the following:

(a) Light naphtha fractionation that produces feed for the isomerization reaction section, butane for the alkylation plant, and heptane and heavier, which are used as virgin aviation base to the extent needed, the remainder going to motor gasoline.

(b) Naphtha isomerization reaction and HCl production section, which produces isomate as feed for the isomate fractionation section, butane for the alkylation plant, and refinery fuel gas. The naphtha isomerization unit is supported by a hydrogen plant, which produces hydrogen employed to inhibit cracking in the isomerization reaction.

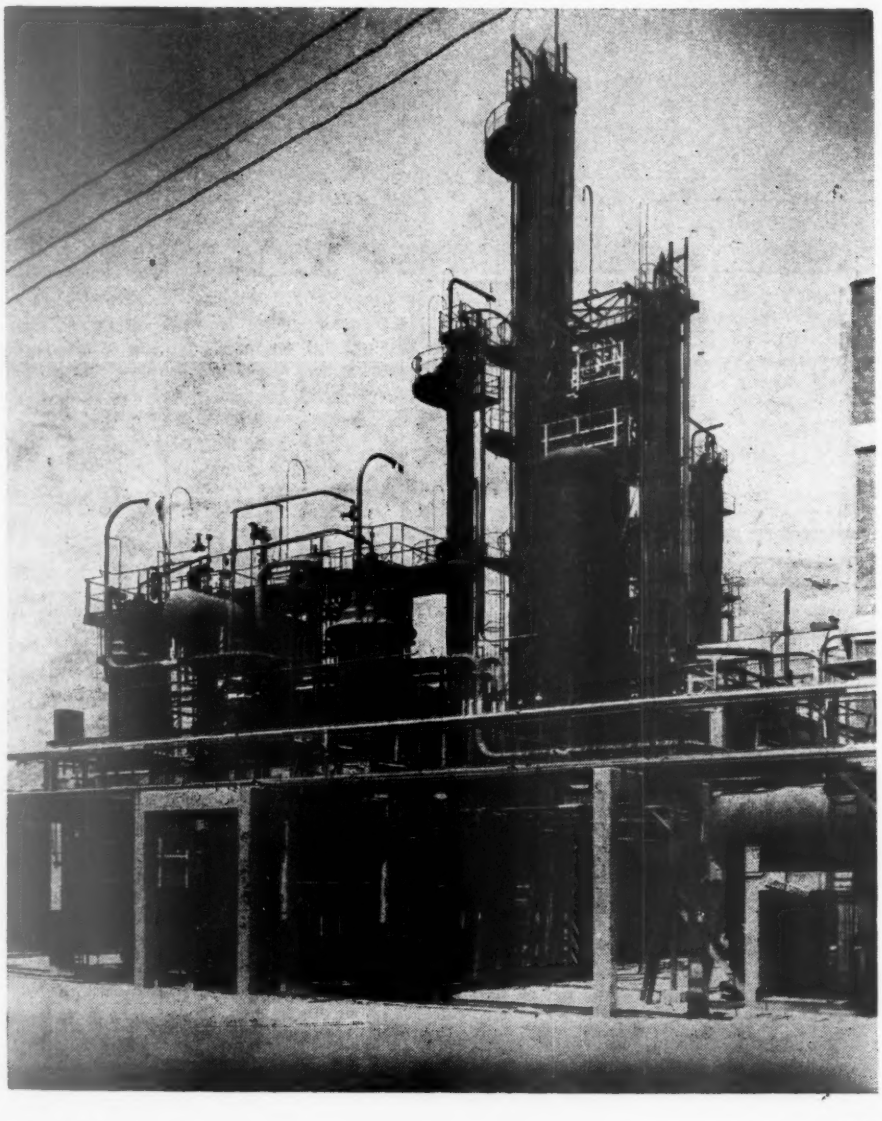
(c) Isomate fractionation, which selectively fractionates the higher boiling, low octane number isomers from the isomate for recycle to the isomeri-

TABLE 3
Typical inspection of charge and products

	Naphtha fractionation			Naphtha isomerization		
	Debutanizer feed	Depentanizer bottoms	Depentanizer sidestream	Fresh feed	Neohexane product	Naphthene product
Gravity, °API	75.8	61.1	This stream is the fresh feed for naphtha isomerization	80.5	87.5	52.7
ASTM distillation, °F*						
Initial	88	188		114	103	198
5 per cent rec.	101	198		122	107	201
10 per cent rec.	107	209		124	109	203
20 per cent rec.	120	211		128	110	207
30 per cent rec.	138	213		130	111	211
40 per cent rec.	154	218		134	113	214
50 per cent rec.	174	223		138	115	219
60 per cent rec.	193	229		144	120	224
70 per cent rec.	213	237		150	123	233
80 per cent rec.	229	247		156	128	249
90 per cent rec.	261	263		164	133	303
95 per cent rec.	.....	282		168	.....	405
Maximum	300	320		182	138	445
Loss	4 per cent	.....		2 per cent	2 per cent	.....
Reid vapor pressure, lb. per sq. in.	16.0	1.4		8.9	12.4	1.4
Octane rating						
ASTM motor method, clear		54.9		68.6	84.3	71.6
F-3 method (1-C), + 4.6cc. Tel.		82.0		94.9	100+1.57	88.9
Component analyses of lighter products, liq. vol. per cent						
Naphtha fractionation	C_3	i-C_4	n-C_4	i-C_5	n-C_5	C_6+
Debutanizer overhead	4.8	92.7		2.5	.....	.....
Depentanizer overhead	.....	.....	.....	46.6	46.3	7.1
Naphtha isomerization						
Butane product (Isomate debutanizer)	5.5	43.9	8.1	36.9	5.6	.....

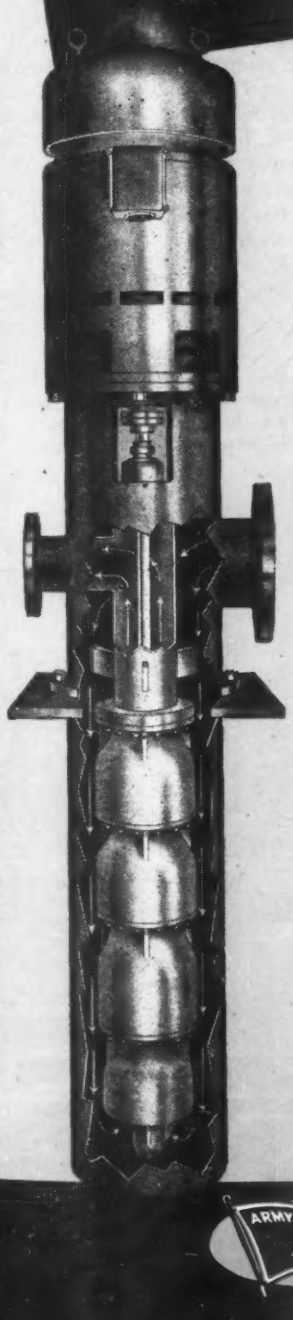
*Corrected to sea level.

Naphtha isomerization reactors. Left to right: Reactor, hot settler, reactor, isomate debutanizer, neohexane tower, vertical surge drum, naphtha depentanizer, spent complex drum.



Vessels need not be elevated or pits excavated to secure added net positive suction head

When pumping light hydrocarbons, added costs, frequently necessary to provide sufficient npsh, either by raising the vessel or providing an elaborate pit to lower the pump, may be eliminated by the use of the Byron Jackson VMT Pump. This pump consists of a multi-stage pumping unit mounted in a barrel from which it takes suction. Base of the pump is at surface level, while the length of the barrel below is determined by the npsh requirement. This arrangement permits setting suction vessel at a lower elevation. Pumps have been standardized in four sizes with 8, 10, 12 and 14 inch barrels. These cover capacities to 1000 gpm, against heads up to 250 psi, and with standard materials are applicable for temperatures to 250° F. Larger sizes can be furnished to 5000 gpm, and all sizes with suitable materials for corrosive liquids and/or temperatures to 750° F. on special order. Write for new VMT Pump Bulletin.



Three of a series of Byron Jackson VMT Pumps used by Cities Service Company, Lake Charles, La., in feeding, charging, extracting, returning and transferring acetate, butane and butadiene.

ARMY E NAVY

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zation section reactors and makes a product largely consisting of isopentane and neohexane for aviation blending.

From the above, it will be noted that the hexanes are recycled from the isomate fractionation section to the isomerization reactors, whereas the pentanes are handled in the isomate fractionation section in an once-through operation.

The naphtha fractionation section is charged with light naphtha at a rate of 1750 bbl. per day and the neohexane product yield is 1061 bbl. per calendar day. Table 3 shows typical inspections of the unit's charges and products, and the component analyses of lighter fractions.

▸ **Light naphtha fractionation.** The light naphtha fractionation section consists of a 30-tray debutanizer and a 40-tray dependanizer.

Virgin light naphtha, produced in Plant No. 1 and sent to storage, is charged into the unit and passes through a low pressure 15-lb. steam preheater for preheat to a temperature of 225°F. before entering the debutanizer over the 13th or 17th tray. The debutanizer is designed for a pressure of 110 lb. Its temperatures are: Bottom, 275°F.; top, 140°F.

The top product of this column is C_4 and lighter, which, after passing through a condenser and out the reflux drum, splits with a portion of the drum overhead refluxing the column over the top tray while the balance goes to storage as feed to the alkylation and butane isomerization plant. Bottoms, pentane and heavier, are feed to the depentanizer. This column is served by a high pressure steam reboiler designed for a duty of 6,167,000 B.t.u. per hr.

Pentane and heavier enters the depentanizer over the 24th or 28th tray. The column is designed for a pressure of 60 lb. Its temperatures are: Bottom, 290° F.; top, 170°F.

The depentanizer's overhead is pentane, which, after passing through a condenser and reflux drum, goes to motor fuel storage while provision is made for feeding it to the naphtha isomerization section.

This depentanizer has a side stream, pentane and hexane, drawn off at the 6th, 9th, or 12th tray, and this fraction goes to the naphtha isomerization section. Bottoms, heptane and heavier, pass through a bottoms cooler and go to aviation gasoline or motor gasoline storage. The depentanizer is served by a high pressure 240-lb. steam reboiler designed for a duty of 9,920,000 B.t.u. per hr.

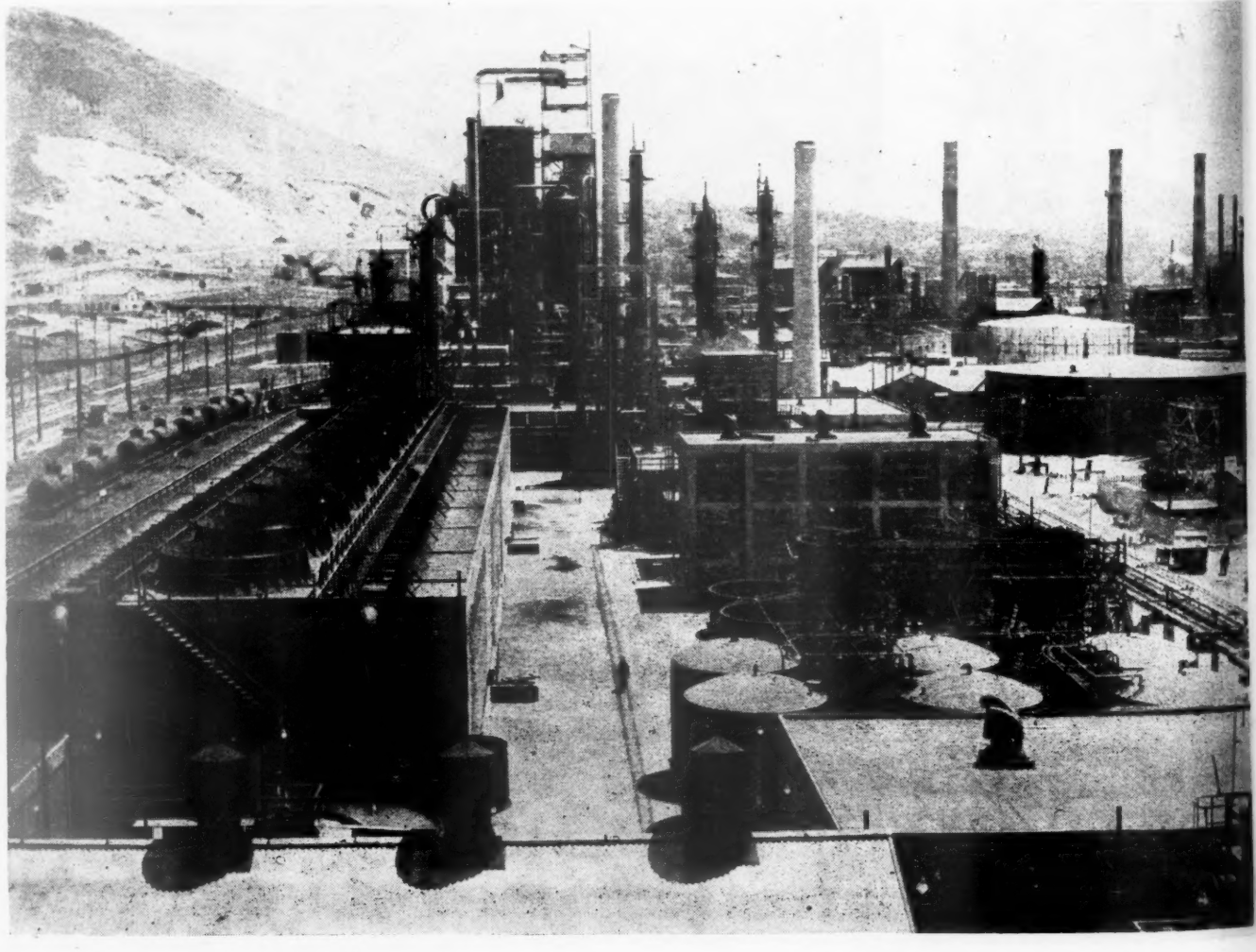
▸ **HCl absorber.** The pentane-hexane side stream from the light naphtha fractionation section depentanizer meets the hexane recycle overhead stream from the isomate fractionation section heptane tower and, in a common line, these enter a feed storage drum for pumping through a calcium chloride drier for removal of any water content, and then through a sand filter for removal of entrained calcium chloride fines before entering the HCl absorber as lean oil.

The function of the HCl absorber is to recover HCl from the tail gas by contacting it countercurrently with the pentane-hexane stream. The tail gas, relatively free of HCl, is released overhead and the rich oil bottoms consisting largely of C_5 and C_6 and HCl pass to the HCl absorber bottoms drum. In normal operation there is substantially no loss of HCl from this tower.

The absorber is designed for a pressure of 335 lb. Its temperature, bottom and top, is 92°F. It contains 4 ring-packed sections, the bottom section consisting of 9 ft. 3 in. of 1-in. by 1-in. rings followed by a 9 ft. 6 in. section containing ¾-in. by ¾-in. rings, and 2 top sections, each 9 ft. 6 in. packed with ⅝-in. by ⅝-in. rings. Below each absorber section is 6 in. of 1½-in. berl saddles. A redistribution plate separates the 3 top sections.

The lean oil feed enters the absorber

General view showing Marley 12-cell double-flow cooling tower, alkylation refrigeration compressor house, sulphuric acid tanks, alkylate sludge separators, raw hydrogen and inert gas holders. In the background: Vapor recovery unit towers and fluid catalytic cracking unit.



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Vogt HEAT TRANSFER EQUIPMENT

1. Heat Exchangers in the foreground have monel metal shells, admiralty metal tubes and naval bronze tube sheets, floating head covers, and baffles. Vogt Ell Bolts are used on floating head covers.
2. Reactors for catalytic polymerization units being assembled and tested. Each is of welded construction and has bolted-on hinged covers.
3. Group of Diesel Oil Exchangers for a visbreaker. Used to exchange heat between diesel oil and corrosive crude containing salt and sulphur compounds.
4. 62"x30'-6" long Gas Cooler for a catalytic unit in a large refinery. Tube bundle at right is for a second unit.

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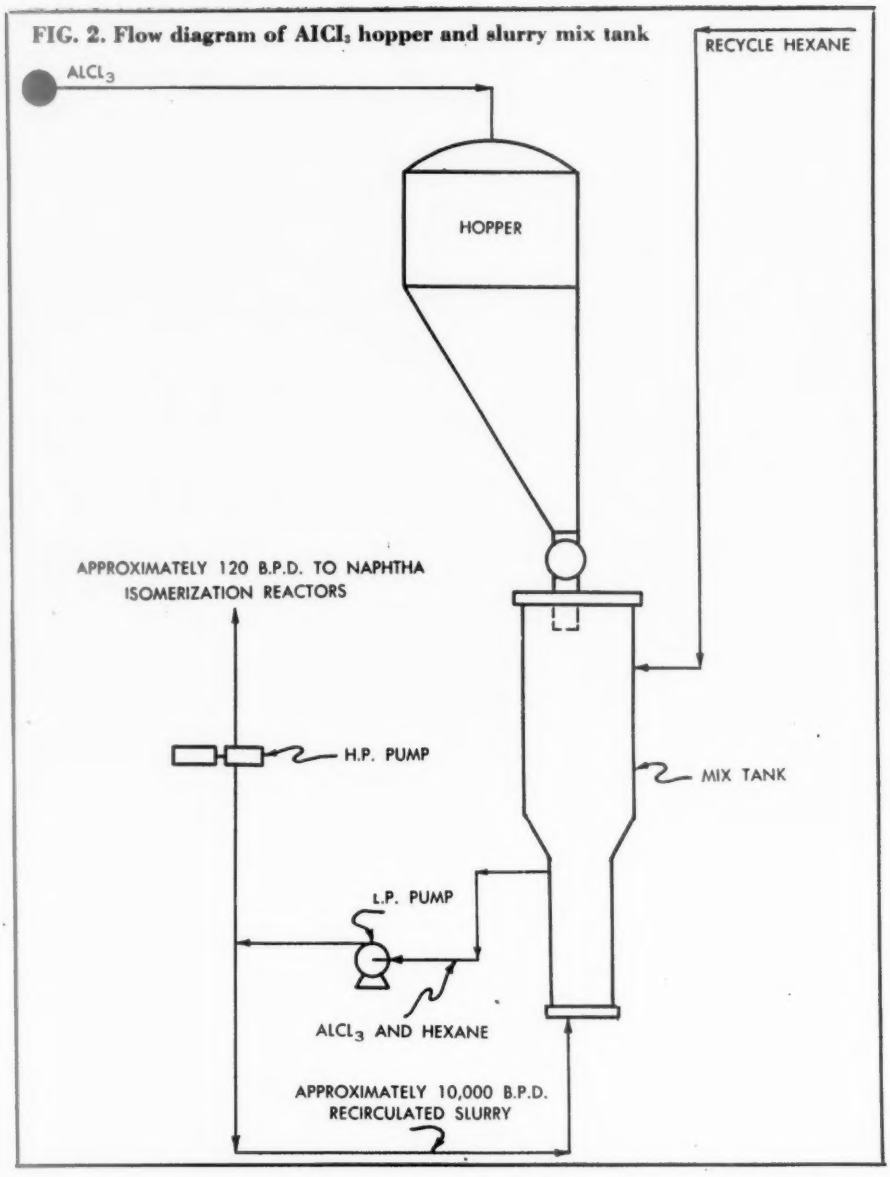
FIG. 2. Flow diagram of $AlCl_3$ hopper and slurry mix tank



at the top. A stream of recycle gas from the top of the HCl stripper tower, plus a light gas flashed off the cold settler and HCl, enters the absorber under its bottom ring-packed section. The overhead tail gas goes to a tail gas caustic scrubber and out overhead to refinery fuel. Bottoms, C_5 and C_6 plus HCl, go to the HCl absorber bottoms drum, which provides surge capacity from which the reactor charge pumps take suction. The drum is vented back to the absorber. Bottoms from the drum are pumped by the reactor charge pumps through an exchanger where they exchange against HCl stripper bottoms and then go to a high pressure steam preheater. Following preheat to a temperature of 250-300° F. the stream meets hydrogen feed from the hydrogen plant and now is ready to enter the reactor system.

▸ **Reactor system and process.** There are 2 reactors in series operating at a temperature of 250°F. However, under operating conditions as conducted to date, design production both for quality and quantity has been readily met with only one of the reactors in operation at a time. The liquid charge enters the base of the first reactor and isomerizes as it rises upward contacting the liquid catalyst. The effluent, overhead from the reactor, goes to a hot settling drum operating at reactor temperature where entrained liquid catalyst settles out and goes to spent catalyst storage.

The catalyst is a liquid complex formed by the reaction of $AlCl_3$ and hydrocarbons. It is a dark mobile liquid having a specific gravity of about 1.5 and a viscosity somewhat higher than SAE 50 lubricating oil. In the reactor, the feed contacted by the catalyst complex in the presence of HCl and H_2 reacts to form an effluent rich in the desired branch-chain aliphatic hydrocarbons of high-octane number. The reaction is continuous.

$AlCl_3$ is soluble in hydrocarbons; however, due to the characteristics of the catalyst complex employed, it is rendered substantially insoluble and, in the hot settler, its separation from the effluent is readily effected.

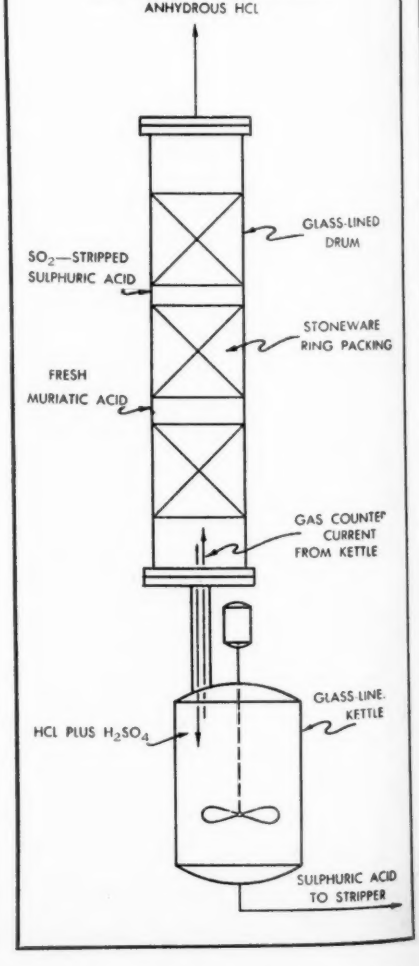
The function of the stream of H_2 introduced into the reactor is to inhibit cracking.

▸ **Catalyst cycle.** The liquid catalyst complex is formed in the reactor by the reaction of makeup $AlCl_3$ and a very small portion of the reactor charge. The makeup $AlCl_3$ is pumped into the reactor as a slurry formed by introducing a portion of the recycle hexanes from the heptane tower overhead. The slurry is formed in a mix tank (Fig. 2).

The mix tank hopper has a rotary feed at its base. A standpipe extends from the rotary feed about 6 in. into the mix tank proper. Granulated $AlCl_3$ from storage enters the hopper overhead and is admitted to the mix tank by the rotary feed.

A line of recycle hexanes, overhead from the isomate fractionation section heptane tower, enters the top of the liquid-level controlled mix tank and mixes with the granulated $AlCl_3$ to form a slurry. Intimate mixing of the granulated $AlCl_3$ and the hexanes is accomplished by recirculation of the slurry, which is withdrawn through an outlet positioned approximately below the center of the mix tank by a low pressure circulating pump and recirculated back into the mix tank bottom at a rate of approximately 10,000 bbl. per day. The intimately mixed $AlCl_3$-hexane slurry is drawn from the circulating line at a rate of about 120 bbl. per day by a high pressure pump to the reactor. As complex is formed in the reactor, the catalyst level builds up until both the complex and the hydrocarbon overflow together to the hot settler. Spent catalyst is withdrawn from the hot settler and is sent to

FIG. 3. Schematic diagram of HCl generator.



Cylinder life multiplied by 5

Cylinder life that is multiplied by 5 is the experience of a large city bus company who made the comparison between PORUS-KROME cylinders and ordinary cylinders in the same engines.

The reason that cylinders last longer when they have been treated with PORUS-KROME, applied by the Van der Horst process, is that it resists wear and corrosion better than any other known cylinder material.

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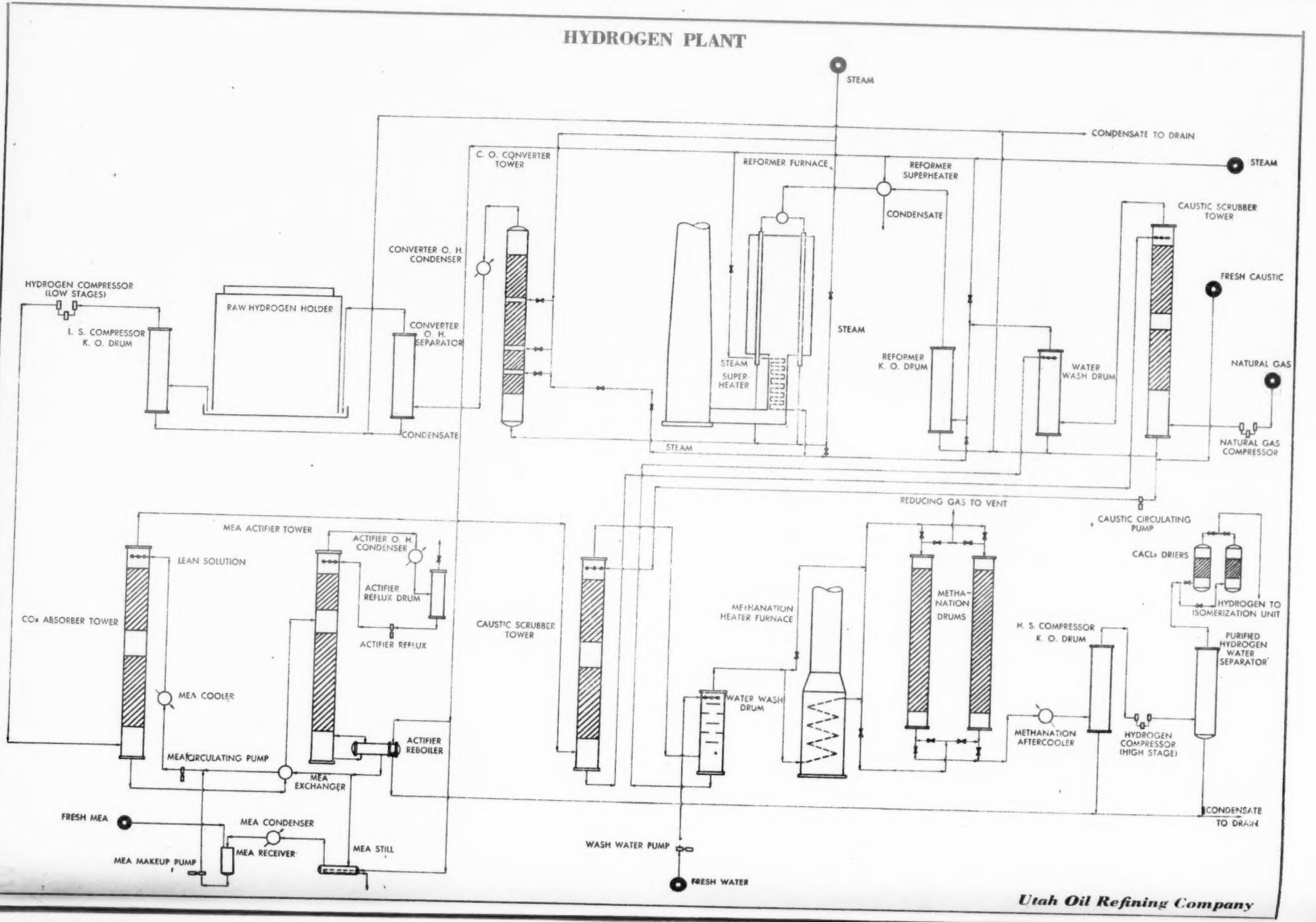
HYDROGEN PLANT
STEAM
CONDENSATE TO DRAIN
STEAM
C. O. CONVERTER TOWER
REFORMER FURNACE
REFORMER SUPERHEATER
CONDENSATE
CAUSTIC SCRUBBER TOWER
CONVERTER O. H. CONDENSER
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STEAM
REFORMER K. O. DRUM
WATER WASH DRUM
FRESH CAUSTIC
NATURAL GAS
NATURAL GAS COMPRESSOR
CONDENSATE
STEAM
REDUCING GAS TO VENT
CAUSTIC CIRCULATING PUMP
MEA ACTIFIER TOWER
ACTIFIER O. H. CONDENSER
LEAN SOLUTION
CACL2 DRIERS
ACTIFIER REFLUX DRUM
HYDROGEN TO ISOMERIZATION UNIT
CO2 ABSORBER TOWER
CAUSTIC SCRUBBER TOWER
METHANATION HEATER FURNACE
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WATER WASH DRUM
ACTIFIER REBOILER
METHANATION AFTERCOOLER
HYDROGEN COMPRESSOR (HIGH STAGE)
MEA CIRCULATING PUMP
MEA EXCHANGER
CONDENSATE TO DRAIN
FRESH MEA
MEA CONDENSER
MEA RECEIVER
MEA STILL
WASH WATER PUMP
MEA MAKEUP PUMP
FRESH WATER
Utah Oil Refining Company

TABLE 4

Typical inspections of anhydrous HCl generator charge and products

Input		
Muriatic acid feed	31.4	wt. per cent HCl
Sulphuric acid feed*	66° Be.	93 per cent sulphuric
Output		
Anhydrous HCl	99.9 per cent HCl	0.1 per cent sulphur oxides
Tail sulphuric acid	64.8° Be.	88 per cent sulphuric

*Recovered black acid.

complex storage. Complex from the storage drum is hauled away to an isolated area and dumped with an excess of crushed limestone.

HCl generator system. Anhydrous HCl is made in an HCl generator (Fig. 3) by dehydrating 22° baumé hydrochloric acid with sulphuric acid.

The HCl generator consists of a glass-lined, ring-packed column that has a glass-lined agitation kettle beneath it.

Sulphuric acid from storage is pumped to the top of a small ring-packed SO_2 stripper. Inert gas, blown through this stripper, strips free SO_2, which is vented to atmosphere. The stripped sulphuric acid is then pumped to the HCl generator, entering it above a feed line carrying HCl from storage to the generator. Contact of the H_2SO_4 removes the water from the HCl.

Mixed HCl and H_2SO_4 flow down to the glass-lined kettle where the mixture is vigorously agitated to complete the reaction between the acids. Spent H_2SO_4 with a trace of HCl goes from the bottom of the kettle to a ring-packed H_2SO_4 stripper. Inert gas is blown through the stripper to remove traces of HCl. The inert gas and HCl are vented to atmosphere. Tail H_2SO_4 from the stripper bottom is pumped to the acid concentration plant.

Anhydrous HCl, overhead from the generator, is compressed and cooled. It may be sent to the bottom of the HCl absorber in the naphtha isomerization unit or to the butane isomerization unit. Table 4 shows typical inspections of the HCl generator charge and products.

Isomate debutanization. The overhead product from the hot settler is cooled and goes to a cold settler. Flash gas overhead from the cold settler is recycled back to the bottom of the HCl absorber.

Liquid from the cold settler goes to the top of the HCl stripper. This column is designed for a pressure of 335 lb. Its temperatures are: Bottom, 355°F.; top, 130°F. Feed is over the top tray. The overhead product, which goes to the bottom of the HCl absorber, is HCl, hydrogen, methane, ethane, and a small amount of heavier hydrocarbons. The stripper is served by a 240-lb. steam reboiler designed for a duty of 3,215,000 B.t.u. per hr.

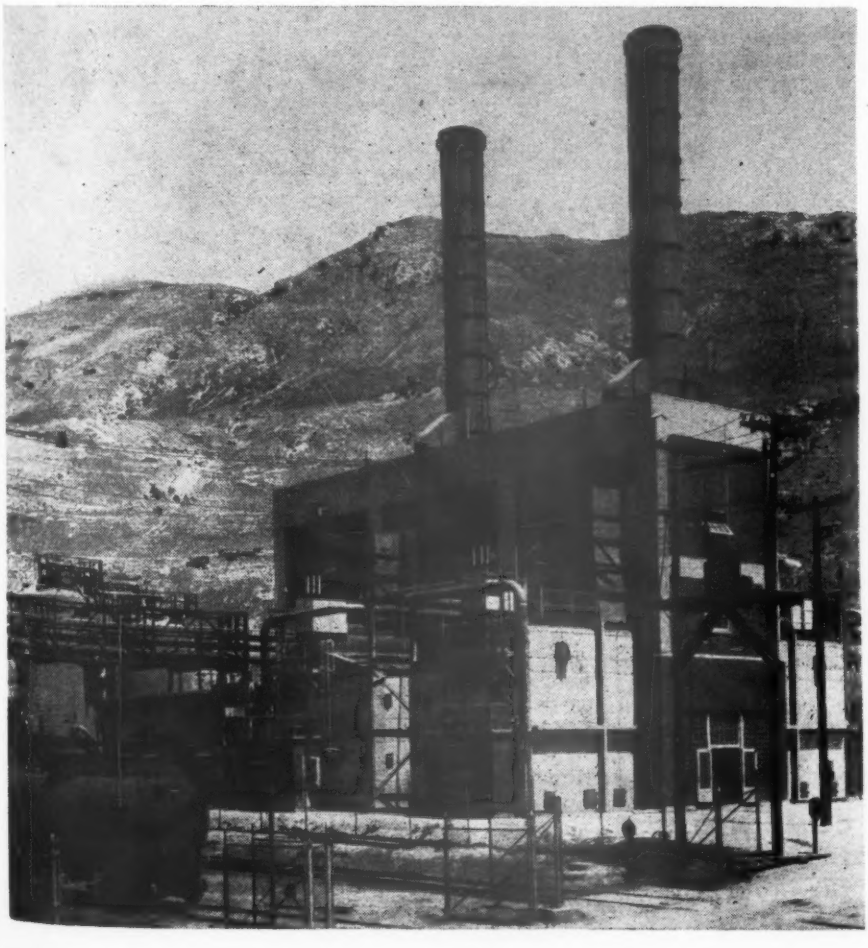
Bottoms from the HCl stripper, the isomerized product containing traces of HCl, are cooled by exchange against the reactor feed, pass through a cooler, and go to a caustic mixer and settler where any traces of HCl are removed. The overhead from the caustic settler is water-washed to remove caustic. The water settler overhead hydrocarbons are preheated to a temperature of 171°F. by exchange against the isomate debutanizer bottoms before entering that debutanizer.

TABLE 5

Typical inspections of hydrogen generator charge and products

	Natural gas feed	Purified hydrogen product
Vol. per cent H_2		88.5
Vol. per cent CO		0.0
Vol. per cent CO_2		1.3
O_2		0.0
C_1	88.5	8.6
C_2	4.6	
C_3 }	7.0	
C_4 }		
Inert		2.8
H_2S grams per 100 cu. ft.	8	
Spec. gravity with respect to air	0.64	0.14

This novel boiler house construction resulted in a 50 per cent saving in building costs. Note boiler structure is outside. The building houses the firing aisle, feedwater heater, deaerator, boiler feed pumps, fuel oil pumps, turbine-driven forced and induced draft fans, condensate filters, and treated-water filters.



The isomate debutanizer is designed for a pressure of 115 lb. Its temperatures are: Bottom, 265°F.; top, 125°F. Its hydrocarbon feed, termed isomate, enters over the 12th or 16th tray.

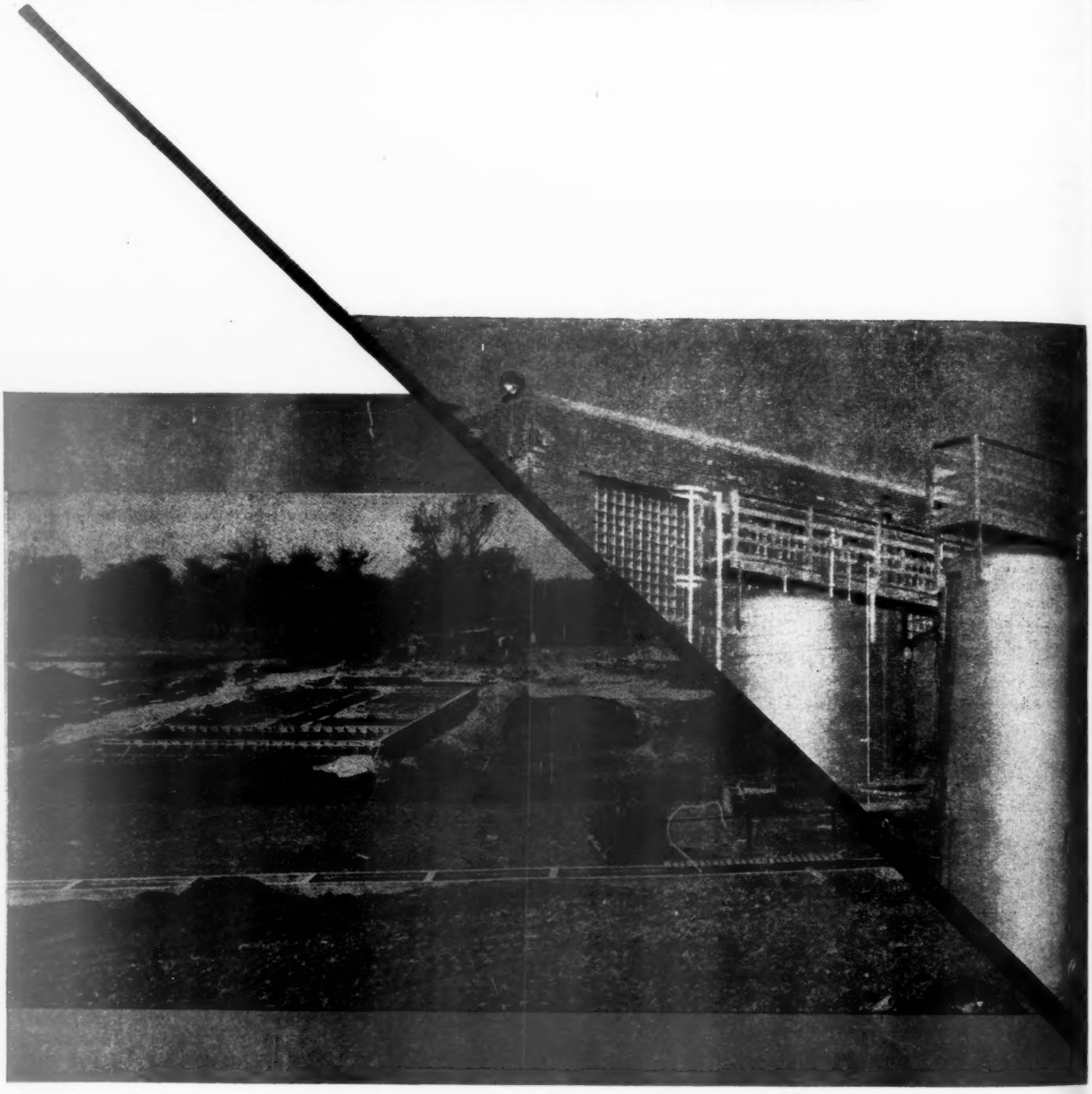
The debutanizer overhead is C_4 and lighter, which goes through a condenser to a reflux drum. Reflux returns over the column's top tray and the C_4 and lighter go to alkylation feed storage. Bottoms, C_5 and heavier, go to the isomate fractionation section hexane tower. The isomate debutanizer is served by a high pressure 240-lb. steam reboiler designed for a duty of 2,680,000 B.t.u. per hr.

Isomate fractionation. Bottoms from the isomate debutanizer exchange against that column's feed and go to the hexane tower, entering it over the 9th or 13th tray. The hexane tower is designed for a pressure of 75 lb. Its temperatures are: Bottom, 262°F.; top, 217°F.

The overhead product of this tower is the desired neohexane and isopentane product, which, after passing through the tower's overhead condenser and reflux drum, is passed through an aftercooler and goes to neohexane storage for aviation gasoline blending.

The hexane tower is served by a 240-lb. steam reboiler designed for a duty of 12,754,000 B.t.u. per hr. Hexane tower bottoms, C_6 plus heavier, go to the heptane tower, the overhead from which is the recycle hexane stream, part of which goes to the catalyst slurry mix tank with the remainder joining the fresh feed to the reactors. *(Continued on Page 98)*

WE WAVED A POTENT WAND



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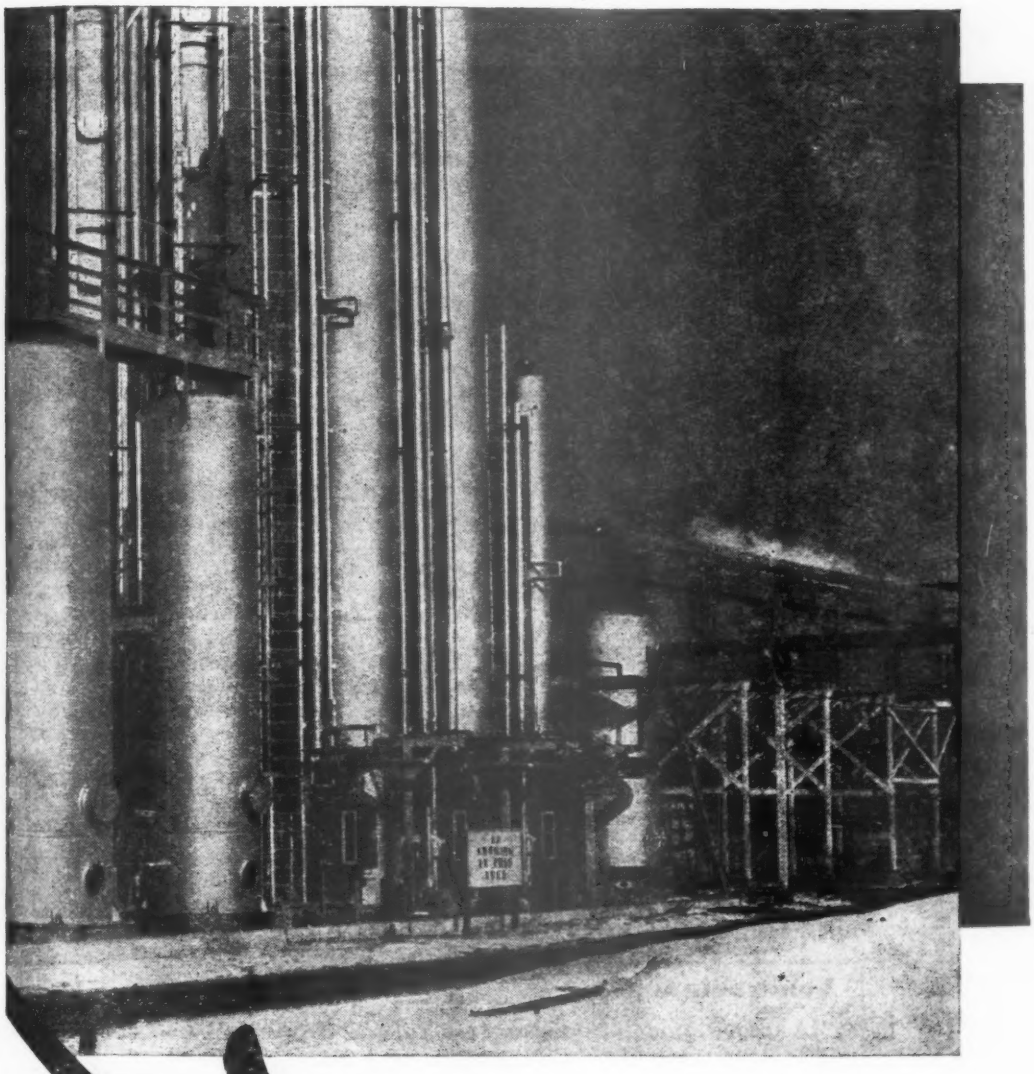

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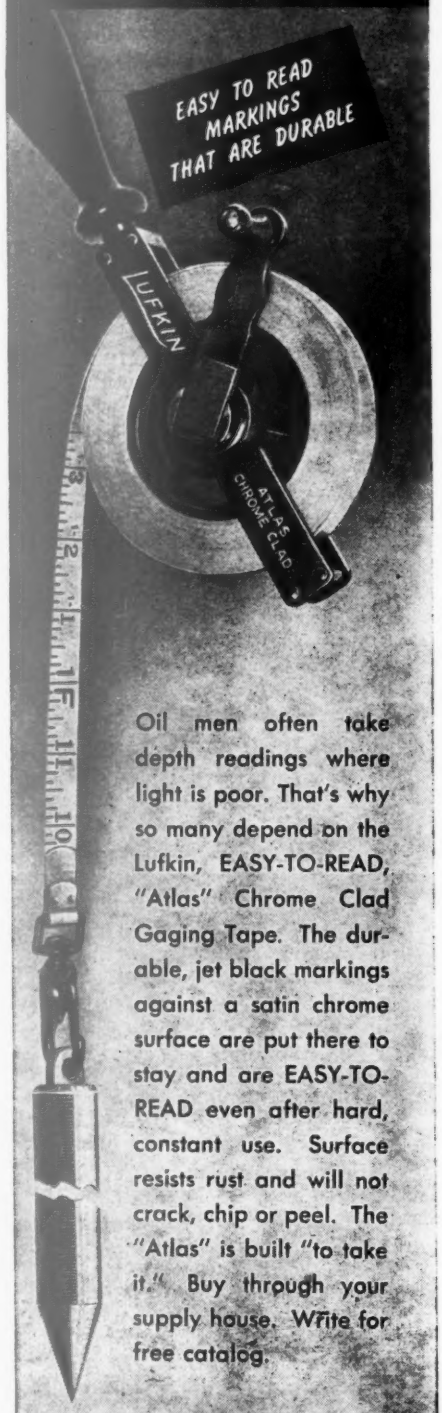

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(Continued from Page 95)

Heptane tower bottoms, rich in naphthenes, go to aviation blending stock storage. The heptane tower is designed for a pressure of 40 lb. Its temperatures are: Bottom, 213°F.; top, 178°F. Feed is over the 9th or 13th tray. It is served by a low pressure steam reboiler designed for a duty of 2,850,000 B.t.u. per hr.

▸ **Hydrogen unit.** Purchased natural gas is charge for the hydrogen plant. Table 5 shows typical inspections of its charge and products.

The natural gas charge is caustic-washed to remove sulphur compounds and then water-washed to remove caustic. Steam is added to the sulphur-free natural gas, which passes through a knockout drum for the removal of liquid, and to make certain the gas is completely dry it is superheated to a temperature of 300°F. by passing through a reformer superheater before entering a reformer furnace. The furnace, which is arranged for down-firing, has a radiant section containing sixteen 25-20 chrome-nickel tubes filled with stanco catalyst.

At a temperature of 1500°F. the product from the furnace is composed of hydrogen, carbon monoxide, carbon dioxide, steam, and traces of feed. This is quenched with steam and passed through a CO converter tower containing a catalyst where the CO is converted to CO_2 accompanied by the production of additional hydrogen.

The effluent overhead from the CO converter is water-cooled to a temperature of 100°F. The effluent is crude hydrogen containing appreciable quantities of CO_2 and traces of CO and unreacted feed. This material goes to a raw hydrogen gas holder and then to a compressor before entering the Girbotol unit.

The Girbotol unit consists of a CO_2 absorber and an MEA actifier. Raw hydrogen enters the CO_2 absorber at its base. The rich bottoms out of the absorber—CO_2 and MEA—are exchanged against the actifier bottoms and enter the actifier for stripping. MEA from the actifier passes through a reboiler, exchanges against the bottoms from the absorber, is pumped through a cooler and thence to the CO_2 absorber as lean solution.

The overhead from the CO_2 absorber is substantially free of CO_2 and passes through a caustic scrubber for the removal of any remaining quantity of CO_2 and sulphur compounds. Caustic is then removed in a water wash.

The gas still contains traces of CO. This is removed by a methanation heater furnace and catalytic reactors. The effluent from the reactors is passed through an aftercooler for condensation of steam and passed through a knockout drum for the removal of condensate. The dry gas, overhead from the knockout drum, is compressed and dried over silica gel, with hydrogen, 88-95 per cent pure, as the unit's end product.

▸ **New boiler plant.** At its own expense and for the exclusive wartime use of the Defense Plant Corporation, the Utah Oil Refining Company built a new boiler plant, unusual due to the fact that it is a semi-outdoor installation.

The boiler plant consists of 4 Babcock and Wilcox 650-lb. design pressure integral furnace boilers with superheaters. Each boiler is fired by 4 steam-mechanical oil and refinery gas burners.

Initially, for Defense Plant Corporation use, based on a feedwater temperature of 220°F., each boiler is designed to produce 65,000 lb. of steam per hr. at a pressure of 325 lb. and 525°F. total temperature at the superheater outlet.

Postwar, with the steam demands of Plant No. 2 reduced, Utah Oil Refining Company will install turbo-generators operating at a pressure of 615 lb., using topping turbines that reduce the steam pressure to 300 lb. for refinery use. The generators will be employed to generate a large percentage of the electric power now purchased.

In the postwar operations, each of the boilers will produce 65,000 lb. of steam per hr. at a pressure of 615 lb. and a temperature of 700°F. total at the superheater outlet. Provision has been made for the future installation of air heaters.

An interesting feature of the boiler plant, designed by Sargent and Lundy, is found in the fact that a concrete building houses only the firing aisle with the boilers outdoors.

As previously stated, solids in raw feedwater are treated out in a hot lime-soda treating plant.

▸ **Acknowledgments.** The writer is indebted to R. G. Clark, chief engineer, C. W. Nysewander, technical service department, and W. W. Rozelle, all of the Utah Oil Refining Company, for much of the information and data from which this manuscript was written, and for the many courtesies extended during his stay at Salt Lake City. He is also indebted to F. E. Johnson, Jr., assistant to the manager of the engineering department, Howard Dimmig, technical consultant to the manager of the engineering department, and J. Warburton, process engineer, all of The M. W. Kellogg Company, for design and flow data provided, and to C. W. Neighbors, Babcock and Wilcox Company, for data concerning the boiler house.

★★★

This is the second and last part of Mr. Kunkel's article. Part 1 appeared in the January, 1945, issue.

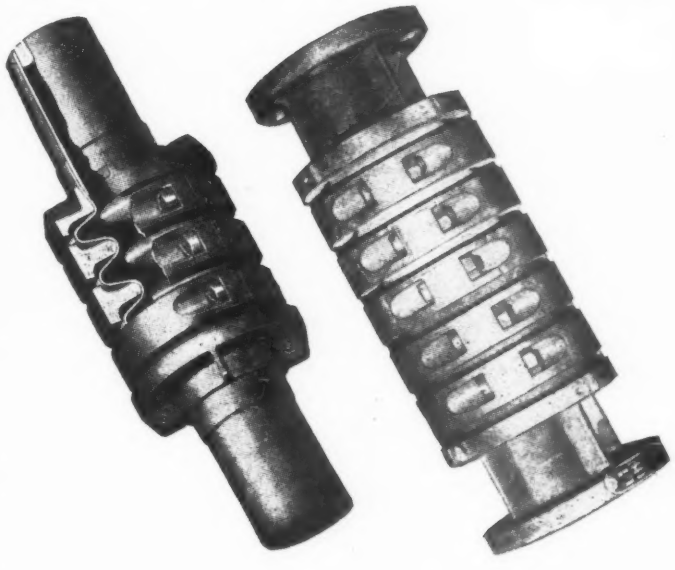
Venezuela lease

A second group of oil concessions covering about 1,000,000 acres in Venezuela has been acquired by the Richmond Exploration Company, subsidiary of the Standard Oil Company of California, according to H. D. Collier, Standard president.

Richmond had recently announced concessions totaling some 1,750,000 acres west of Lake Maracaibo in Venezuela. Most of the new leases are in the delta region of the Orinoco River in the state of Managas.

Milk Bottles and Pipe Lines

Ring Controlled "PACKLESS" EXPANSION JOINTS



WHAT have milk bottles to do with pipe lines? Both react most positively to temperature variations. Under extreme cold, milk expands and comes right out the top of the bottle with little harm done. Under extreme heat, a pipe line expands, but a great deal of harm can be done unless sound steps are taken to compensate for this expansion.

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APPLICATION OF ALIGNMENT CHART TO RAPID SOLUTION OF PRODUCTION FORECASTING PROBLEMS

By **L. R. MERRYMAN,** The British-American Oil Producing Company

EXCLUSIVE THE alignment chart shown in the January issue of *The Petroleum Engineer* was designed to solve problems that require repeated computation when preparing a forecast of production. Although the alignment chart shown herewith does not have so wide an application as the previous one, it can be used to solve problems rapidly that involve division of negative characteristics for logarithms that are confusing unless frequently worked with by the engineer.

The previous chart was designed to solve l, s, or r in the following formulas, which are derived from the laws of geometrical progressions:

A new chart that aids in arriving quickly at production figures, a method first described in the January issue.

$$l = ar^{n-1} \quad \ldots\ldots\ldots \quad (1)$$

Where:

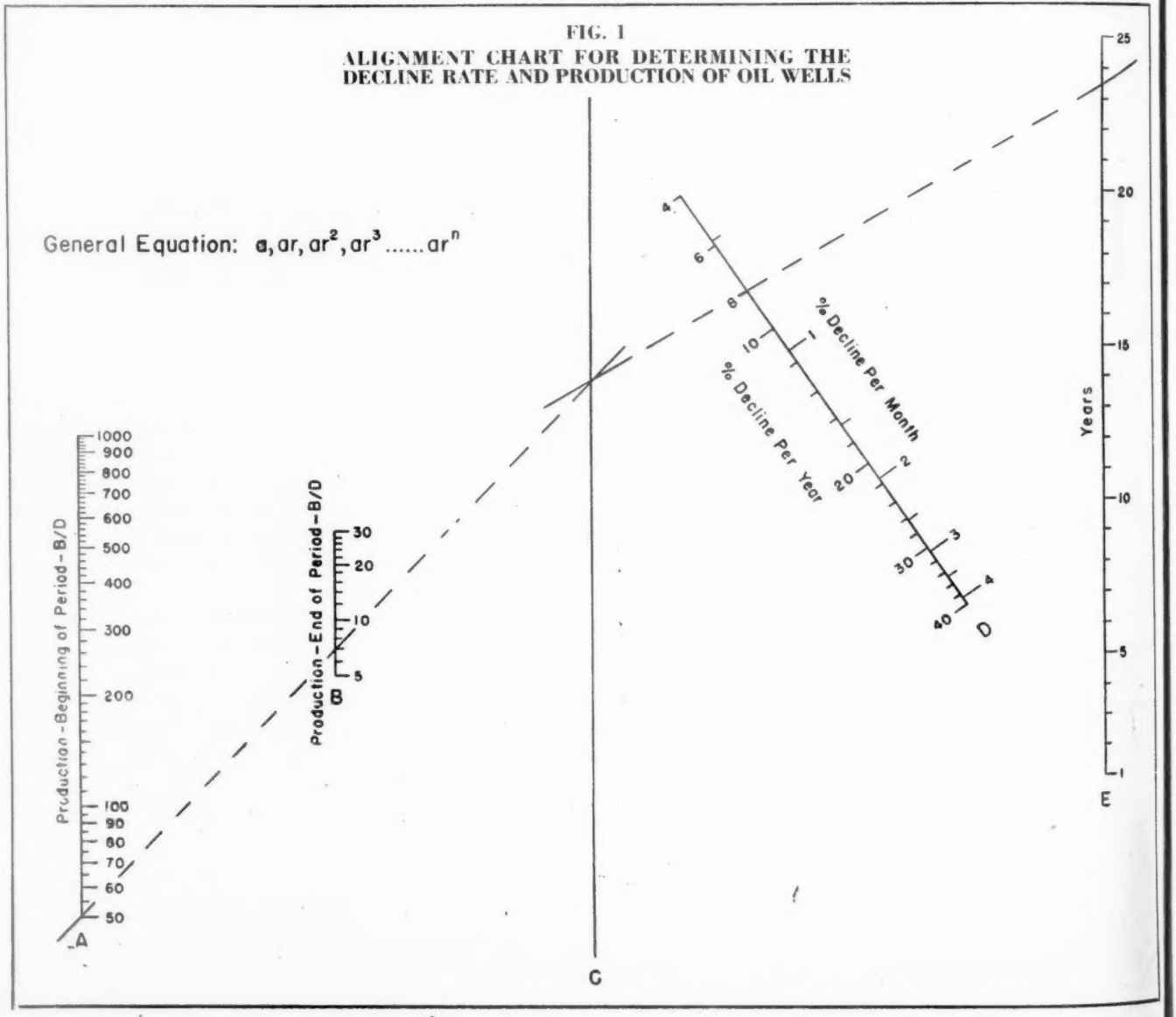
$$s = a\,\frac{(l - r^{n})}{l - r} \quad \ldots\ldots\ldots \quad (2)$$

a = first term, r = ratio,
l = last term, s = sum, and
n = number of terms.

The accompanying chart is primarily designed to solve for n and like the previous chart can be used in reverse to solve for r or l if certain basic data are available.

Theoretically the accompanying chart is applicable only to those wells that are known to decline in conformity with a geometrical series that is also called "ex-

FIG. 1
ALIGNMENT CHART FOR DETERMINING THE DECLINE RATE AND PRODUCTION OF OIL WELLS



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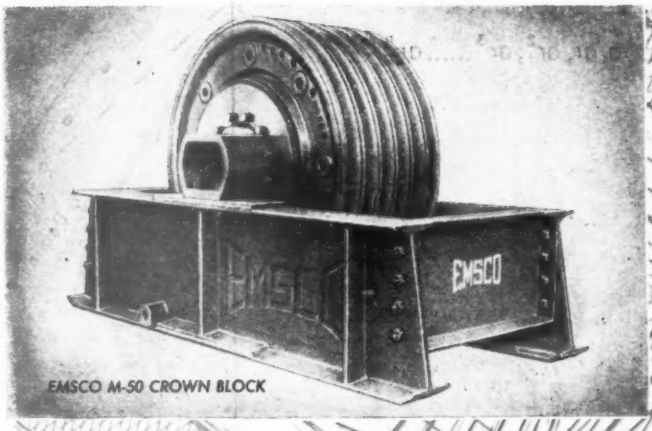
Emsco Crown and Traveling Blocks overcome the inherent problems caused by the trend toward deeper drilling. Deeper drilling has called for blocks with larger sheaves, wider sheave bearings to give more carrying capacity and greater stability. It has meant wider and longer blocks which slow down operations, restrict pipe racking space, and make it impossible to utilize the full height of the derrick.

Emsco Crown and Traveling Blocks eliminate these problems yet retain all of the features essential in deep drilling. On each sheave are double row Timken tapered roller bearings or patented oversized bearings with specially built bearing races, which take care of end thrust, thus eliminating thrust washers and materially cutting down the width of the blocks. Narrowing the blocks permits a shorter center pin supporting the inner races of the bearings, resulting in increased capacity. The sheave and bearing assemblies are interchangeable between the crown and traveling blocks, and the sheaves are accurately balanced and are spaced close together to prevent the wire line from fouling. The dropping speed of an empty Emsco Traveling Block is faster than blocks of conventional design even though they have a substantial savings in weight due to their compact construction. Streamlined to eliminate projections causing hang up, compact for easy handling and shipment, Emsco Crown and Traveling Blocks are made in five sizes to meet all drilling conditions and requirements.



EMSCO M-50 CROWN BLOCK

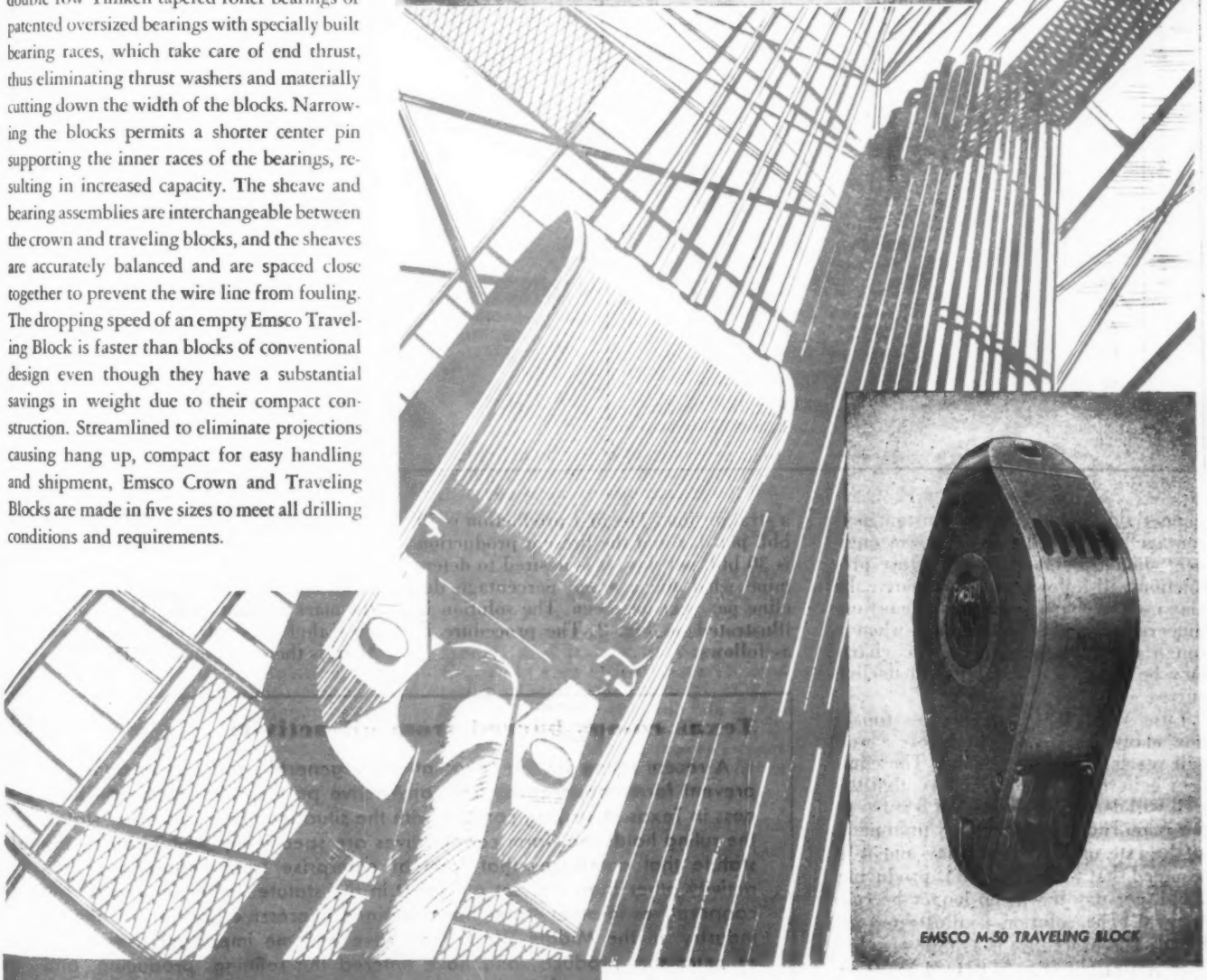


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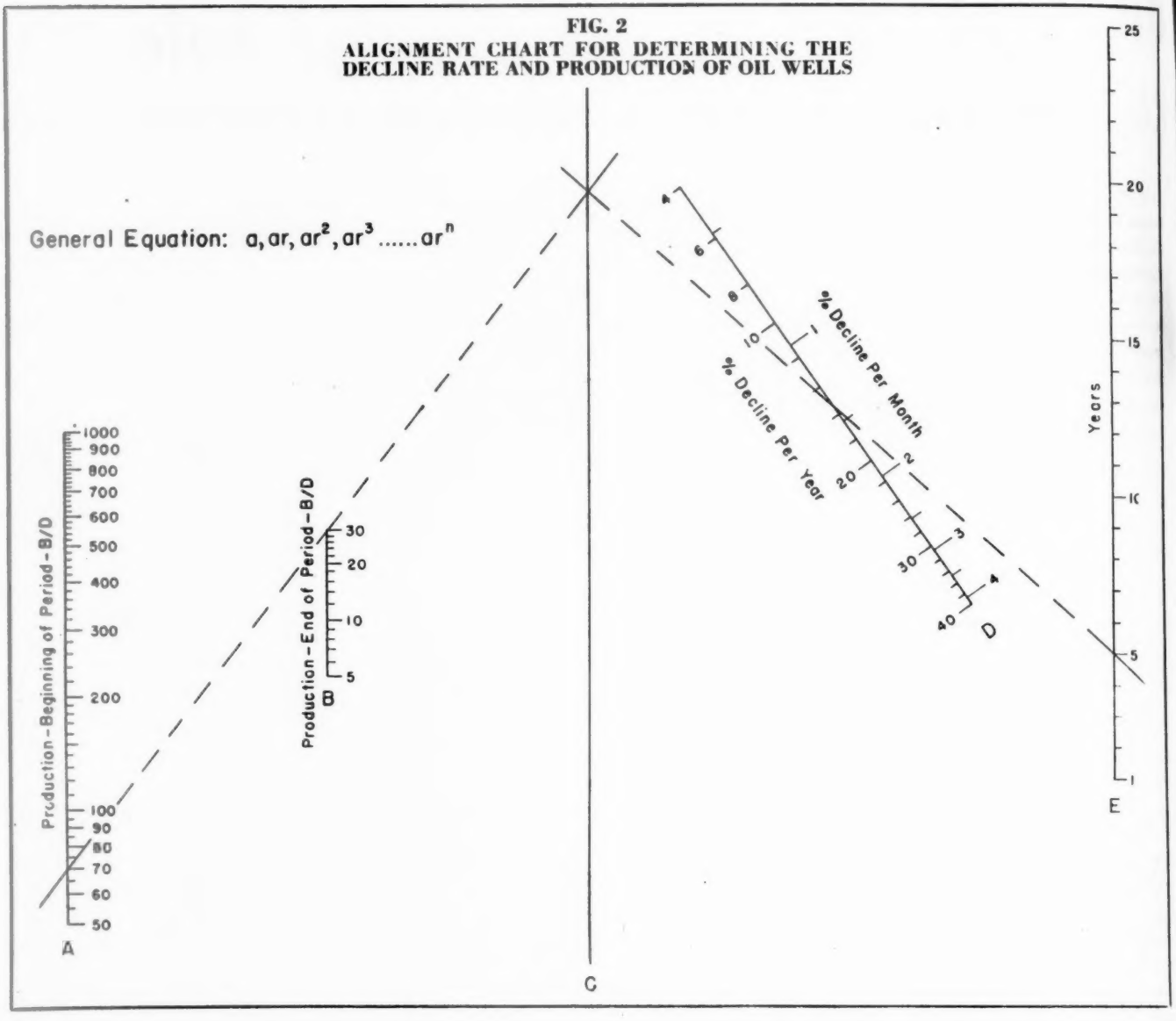
FIG. 2
ALIGNMENT CHART FOR DETERMINING THE DECLINE RATE AND PRODUCTION OF OIL WELLS



ponential," "semilog," or "constant percentage" decline. If, however, an engineer should assume that the future production will follow this type of curve, he may use the chart, and because many engineers make this assumption when a rough estimate will suffice, the charts may be used for many types of decline curves.

Case No. 1. It is desirable to estimate how many years it will be before a well will reach its economic limit. The engineer believes, from past history, that the well will decline at the rate of 8 per cent per year. The well is currently producing at the rate of 50 bbl. per day and it is assumed that when the well is producing 7 bbl. per day it will no longer be economical. The solution is illustrated on Fig. 1. The procedure is as follows:

a. A straight edge is placed at 50 on scale A and at 7 on scale B, then a point is marked on line C.

b. The straight edge is next placed at the marked point on line C and at 8 per cent per year on scale D. The answer, 23½ years, is then read on scale E.

Case No. 2. A five-year production curve on semilog paper shows virtually a straight line. The first production is 70 bbl. per day and the present production is 30 bbl. per day. It is desired to determine what the average percentage decline per year has been. The solution is illustrated on Fig. 2. The procedure is as follows:

a. A straight edge is set at 70 on scale A and at 30 on scale B then a point is marked on line C.

b. The straight edge is next placed at the marked point on line C and at 5 years on scale E. The answer, 15.9 per cent per year, is then read on scale D.

Texas co-ops barred from oil activity

A recent ruling by the Texas attorney general's office is designed to prevent farm cooperatives from any active participation in the oil business in Texas. A striking contrast with the situation in various other states, the ruling holds that farm cooperatives are specifically prohibited by the statute that authorizes that form of enterprise from engaging in any activity other than that set out for it in the statute. In recent years farm cooperatives in other states have attained impressive positions in the oil industry. In the Middle West, they have become important distributors of petroleum products, and have entered the refining, producing, and pipe line divisions of the business.

The recent Texas ruling holds that farm or agricultural cooperative associations cannot engage in the oil business as farm cooperatives and still retain the advantages set up for them by the state and the nation. Chief among the advantages are exemption from income tax and other taxes. The fact that charters of cooperatives permit them to engage in the oil business does not exempt them from the new ruling in Texas.

"General Mud"

FRIEND OR FOE?

In oil well drilling, as in war, mud can be a friend or an enemy. Improperly treated it causes costly damage and delays. Properly treated it speeds up drilling, saves bits, permits easier and faster fishing and formation testing and greatly reduces the danger of "stuck pipe."

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Case No. 3. A well is now producing at the rate of 560 bbl. per day. It is desired to know how much the well will be producing in 15 years. Experience for this type of well justifies an assumption that the well will decline at the rate of 20 per cent per year. The solution is illustrated on Fig. 3. The procedure is as follows:

a. A straight edge is set at 15 years on scale E, and at 20 per cent per year on scale D and a mark is made on line C.

b. A straight edge is then set at the point marked on line C and at 560 bbl. on scale A. The answer, 20 bbl. per day, is then found on scale B.

The accompanying chart is especially useful when it is necessary to make quick approximations of future rates of production. This particular chart was designed to cover a certain class of wells where it is desirable to determine the economic life of a group of wells, which is the reason the "B" scale goes only to 30 bbl. per day. A chart covering larger ranges could be prepared if needed.

In order to utilize the chart it is necessary to have a good record of past production performance for the wells or properties being studied and for the engineer to use sound judgment of economic limits of production and future decline rates. The writer wishes to emphasize that the charts presented this month and last month are only a means of solving the mathematical calculations for the types of wells described and cannot be used to solve the problems of future production until a competent petroleum engineer has determined what conditions will govern future production. The charts, however, will enable a careful user to determine answers in a few minutes that would take hours if it were necessary to make the computations or plot the curves and extrapolate them.

★★★

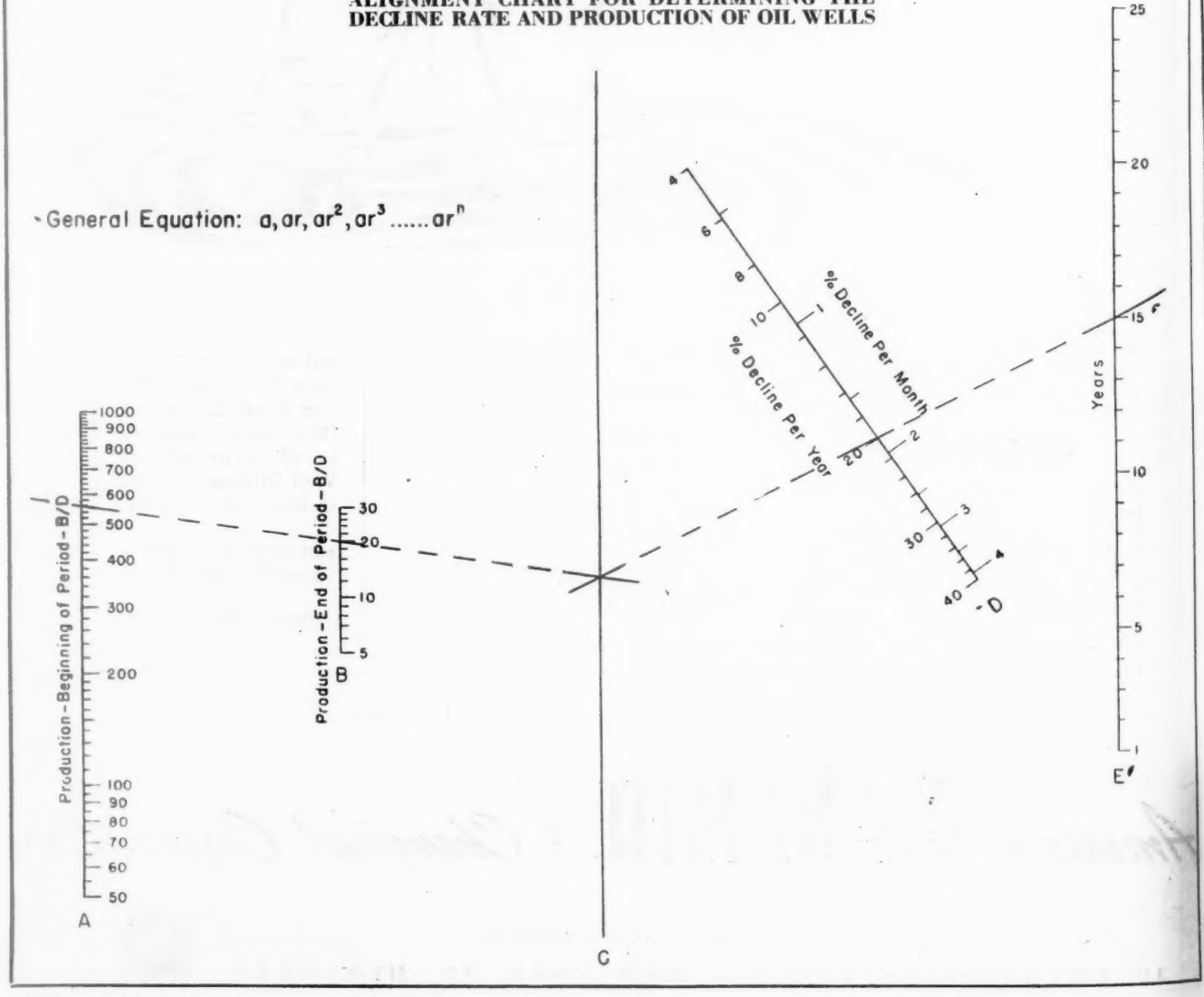
East Texas supplies emergency production

The East Texas oil field, largest in the world, was ordered by the Texas Railroad Commission to continue production of an extra 16,000 bbl. of oil daily through February. In mid-January the commission added one producing day to the schedule for East Texas in order to fulfill an emergency PAW request to keep the Big Inch pipe line from Longview to the East Coast operating at capacity. January had a total of 25 producing days, February a total of 23 producing days. This represents one more production day than usual and raises the daily average output by 16,000 bbl.

Olin Culberson, chairman of the Railroad Commission, said that the East Texas field must yield more oil for possible military needs, even if it necessitates a higher producing rate than engineers recommend.

The 14-year-old East Texas field has 25,000 wells, 15,000 still flowing and 10,000 being pumped. Total production from the field has been more than 2,000,000,000 bbl. of oil.

FIG. 3
ALIGNMENT CHART FOR DETERMINING THE DECLINE RATE AND PRODUCTION OF OIL WELLS



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Brown Line Print *No. 15*

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Gun Test BEFORE you Gun Perforate for Production

Set the casing through the oil, gas and water zones and cement the string solid. Then, run the McCullough Combination Gun Perforator and Tester to perforate and test immediately below the lowest indicated productive zone. This will test the cement job, and show whether bottom water is shut off. If the test shows water, squeeze cement, and gun perforate and test at this point until the water is shut off. Then gun perforate, test and squeeze cement at the top of the zone until a dry job is secured. All productive zones to be produced simultaneously should be gun perforated and tested in the same manner.

After all zones are tested and cemented you can then perforate the selected zones with the customary "6 holes to the foot" with the McCullough Gun Perforator.

This McCullough gun perforator completion method is saving rig time, labor and money for operators and is enabling them to get better wells. Ask any experienced McCullough field man for further information.

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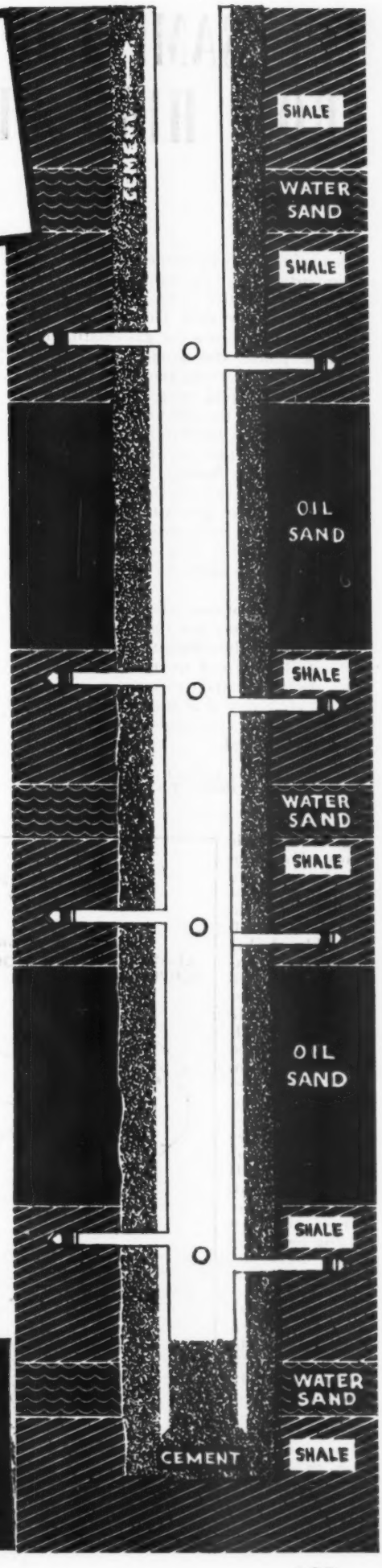

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THE SAMPLING AND METERING OF WET GAS FROM HIGH PRESSURE CONDENSATE WELLS

By **G. G. BROWN** and **D. L. KATZ**, University of Michigan

IN testing wells in condensate fields it is important that the sample taken be truly representative of the entire stream flowing from the well. This is no problem if the stream is a dry gas existing in a single phase. But usually the gas is wet containing varying amounts of liquid as separate liquid phase in the gas stream. Due to the different properties of liquid and gas the flow characteristics of these two phases are different and a sample of the flowing stream taken through a small valve in the line will not contain the same proportions of liquid and gas as the main stream. Very special methods must be used to obtain a representative sample of a two phase stream.

A similar problem was faced by mechanical engineers years ago in their efforts to apply the adiabatic flow calorimeter to testing wet steam. The results were always unsatisfactory and the problem of obtaining a representative sample from a line carrying wet steam has never been solved.

*Presented before Natural Gasoline Association of America, Dallas, Texas, April 12-14, 1944.

The High Pressure Gas Division of the Natural Gasoline Association of America has started to solve this problem by series of tests and a preliminary research program in the Katy gas field, near Houston, Texas. The general plan was to flow a stream of wet gas through a sampling section where a small part of the stream is removed as a sample, and to pass the entire balance of the stream into an efficient separator operated at the same temperature and pressure as a small equilibrium cell or separator on the sample line. By metering the dry gas from, and gaging the rate of liquid accumulation in, the full scale and the small sample separators the accuracy of the sampling technique could be determined. It was also decided to include gas meters on the wet gas stream and to compare the gas rate indicated by the wet gas meters with the total quantity of liquid and dry gas metered after a separation at lower pressure.

Series of tests and research program instituted to determine best means of obtaining representative sample of a two phase stream.

Historical sketch of the testing project. At the Tulsa meeting of the N.G.A. A. High Pressure Gas Division, June 14, 1943, it was decided to make a study of sampling methods over the pressure range from 1000 to 2500 lb. per sq. in. as applied to streams of two phases containing up to 10 per cent by volume of liquid at a condensate well such as supplying the Katy cycling plant west of Houston. It was urged that sampling methods to be most satisfactory should operate with a minimum of pressure drop and that the effect of water and slugging of the liquid be considered. A comparison of vertical and horizontal meter runs

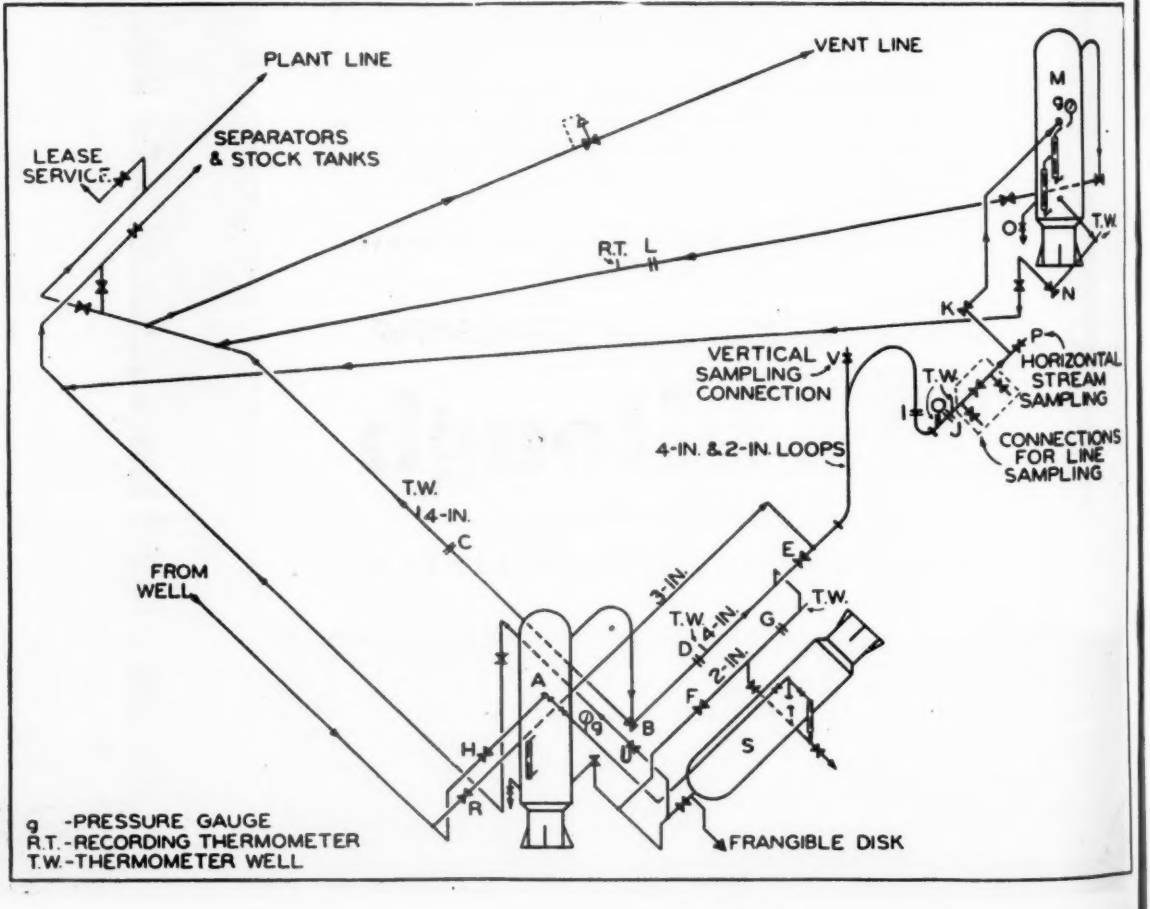

Fig. 1. Isometric flow diagram of the testing equipment. A—3000-lb. separator. B—4-in. adjustable choke. C—Meter on excess gas return line. D—Meter for full scale flow line. E—4-in. gear operated valve. F—2-in. plug valve. G—Meter on 2-in. line. H and R—Control valves for routing of gas from well into equipment. I—Vertical meter setting on testing loop. J—Horizontal meter setting. K—Adjustable choke. L—Meter on gas return line. M—1500-lb. separator. N—Adjustable choke. O—Water drain. P—Horizontal sampling connection. S—1500-lb. separator in horizontal position used as accumulator tank.

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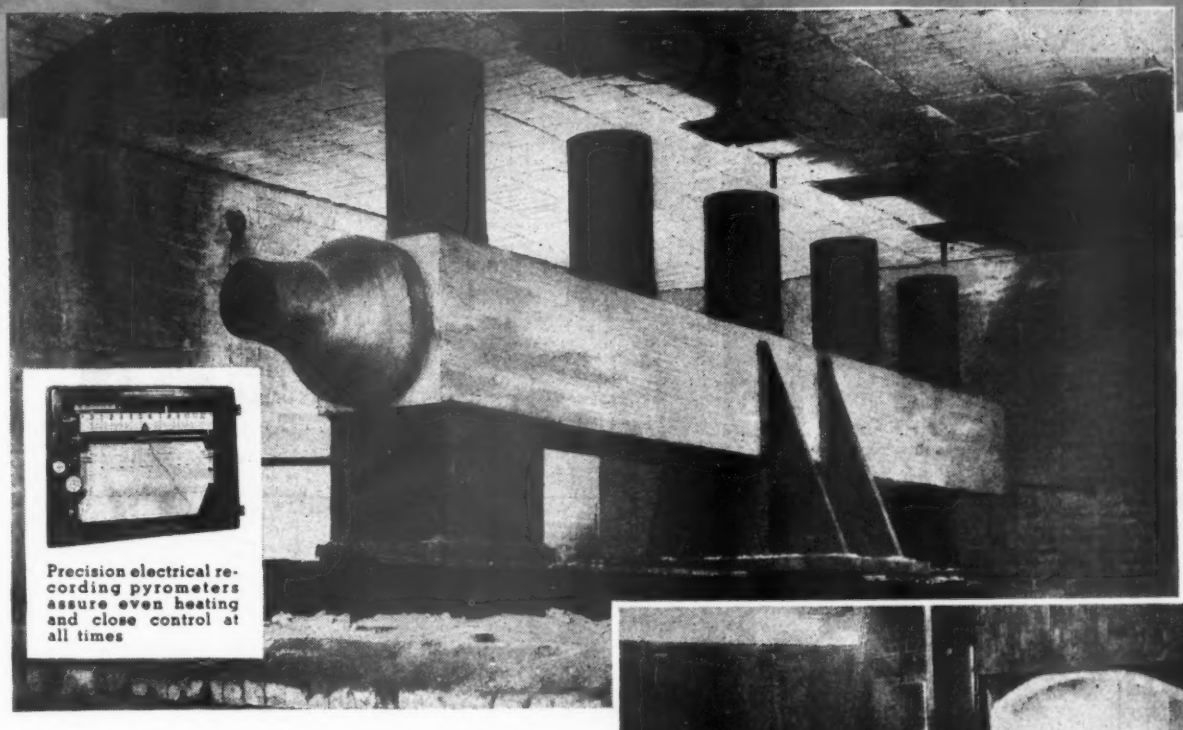
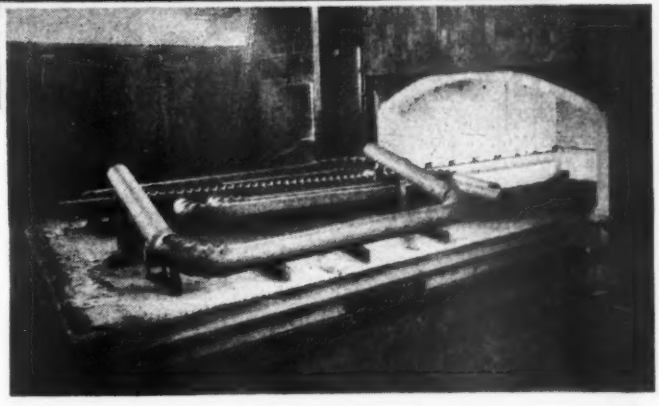


Precision electrical recording pyrometers assure even heating and close control at all times



ABOVE: Group of Creased Bends and Corrugated Pipes being removed from the furnace.

TOP: 20" square forged carbon molybdenum header 18'7" long—in furnace. This header was heated to 1,250°F., held for 10 hours and slowly cooled. Thirty hours were required for the complete cycle.

SHOP fabrication of piping means added protection. Some processes and operations cannot be performed in the field. *All* operations and processes are best performed under controlled shop conditions.

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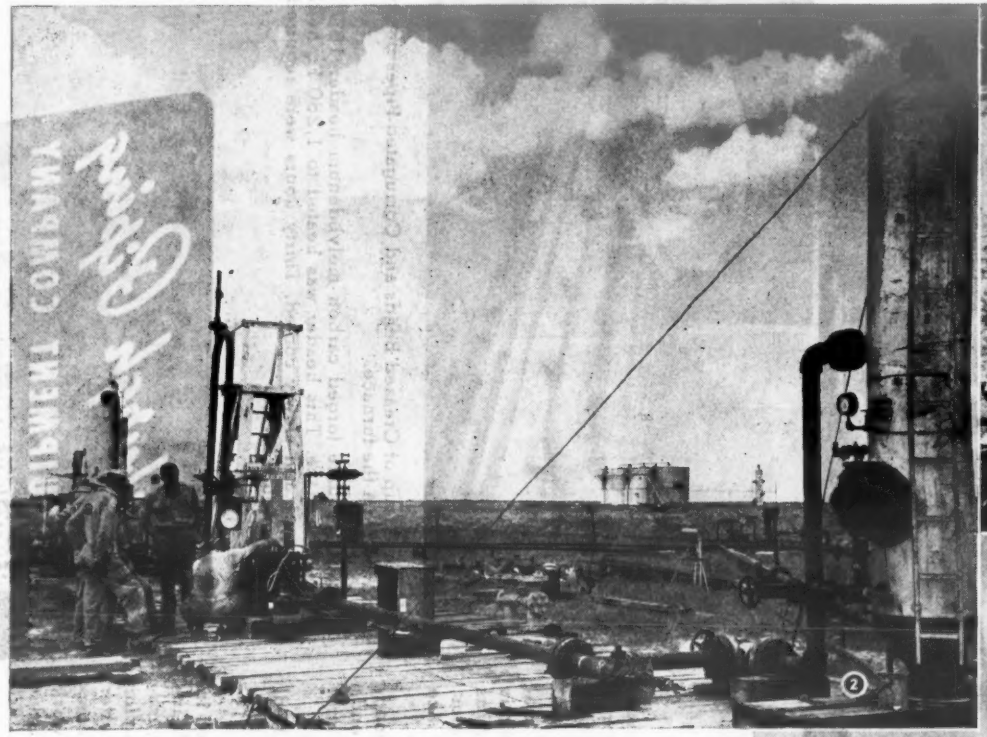
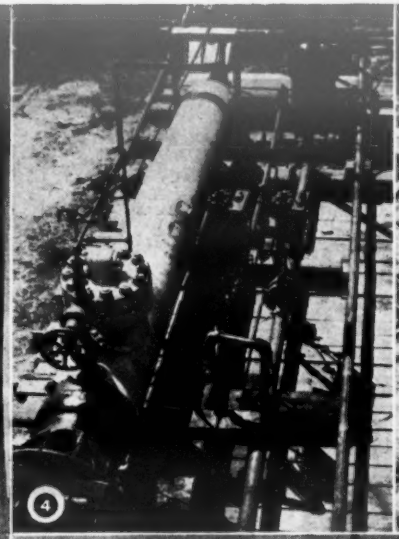
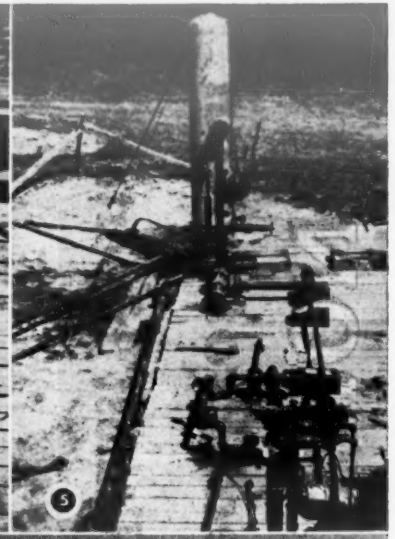


Fig. 2. General view of testing equipment in late construction stage. Flow of gas was from far separator and initial test run was in progress obtaining a gas sample from end of horizontal 4-in. line in foreground.





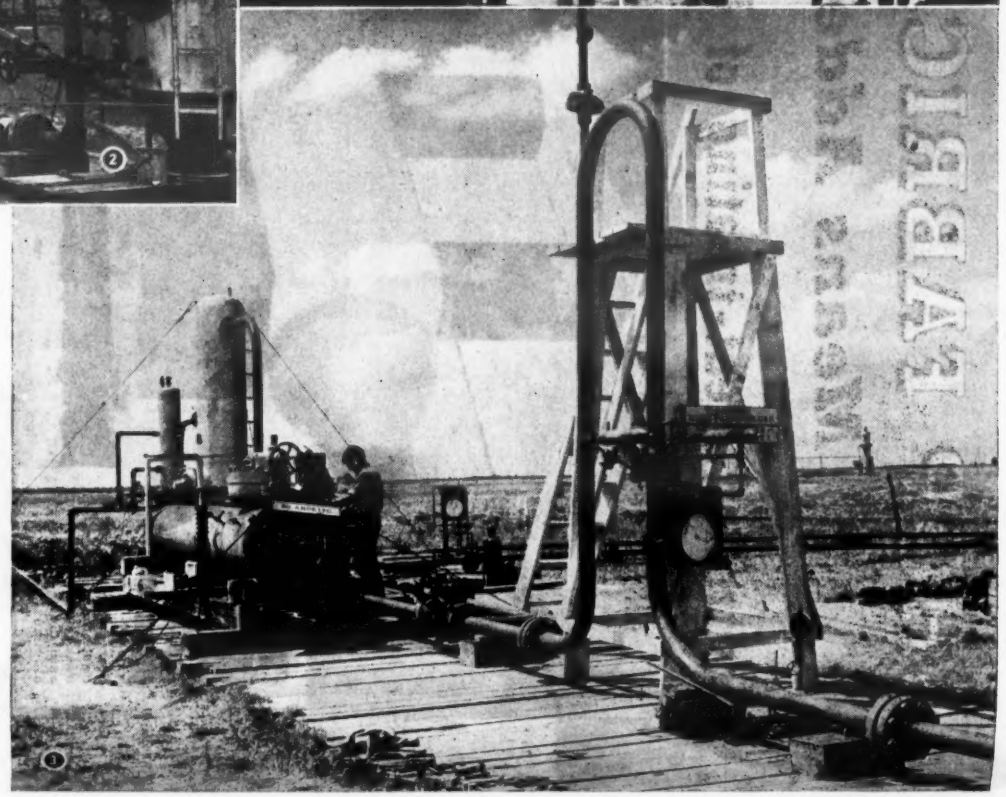
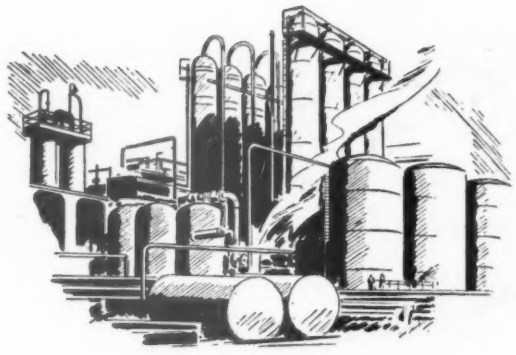


Fig. 3. Taken during construction period and showing meter on 4-in. testing loop and separator laid on its side as liquid storage tank. Experiments were also made with a 2-in. loop. See Fig. 8. Separator in background is on a well adjoining the test site but not connected with it.

Fig. 4. Looking down on the separator storage tank from top of vertical testing loop showing the piping arrangement and meters.

Fig. 5. Downstream side of vertical testing loop showing 2-in. bypass and 2-in. horizontal test section.

Fig. 5. Downstream side of vertical testing loop showing 2-in. by-pass and 2-in. horizontal test section.



70 years of confidence

With 1945 already several weeks old, most folks have settled down to another 365 days of work-to-win effort on the home-front. The war continues to shadow our happiness. Yet all can hope this year's end will find this nation a lot farther along the tough road to Victory.

It happens that, for ourselves, 1945 is a very special year. It is our 70th anniversary. Years totaling three score and ten have passed since Standard's first drilling crew manned a "spring-pole" drill-rig in Pico Canyon of California — and struck oil.

Since then our progress has been steady by jerks — terrific jerks. At first — in the days of the Hayes-Tilden election contest and Custer's last stand—our job was to furnish a better illuminant than whale-oil and candles. Kerosene was the thing.

Came Edison and electricity. Came Ford and automobiles. Our world was overturned—and re-overturned. Gasoline became the thing. And around the corner were the Wright brothers and the airplane.

Now, war has given our business the biggest wrench of all. Oceans of petroleum products — both regular and special — are absolute musts. Hundred-octane aviation gasoline is the thing. Since we're all out for war, it's sure the shift to peace some day will have its problems, too. But, after 70 years in business, we've learned to face every tomorrow with confidence.

We've learned too, that we do best when you do best. In peace as in war, we all depend on one another. Our 70th anniversary can be the sort of year we want, only if it's a good year for you, too. Always, we know at 70, the general welfare is *the* thing.

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E flag, with 3 stars, awarded to our Richmond Refinery

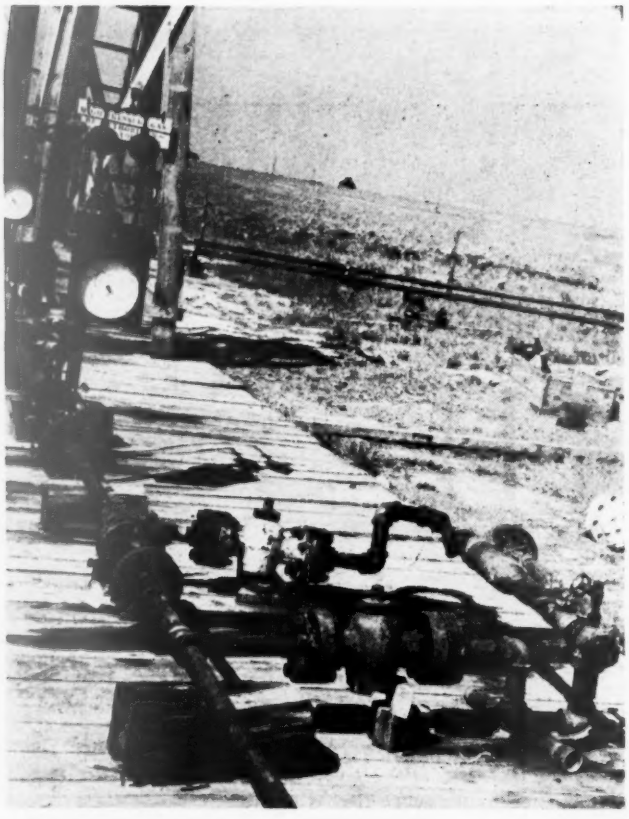


Fig. 6. Detail of 2-in. by-pass with line sampler or mixing device (sometimes called a bazooka) in place ready for testing. Experiments were made with several types of these devices.

Fig. 8. Inserting testing tip in 2-in. vertical loop.

Fig. 7. Preparing to insert testing tip in 1-in. horizontal testing section placed in the by-pass.

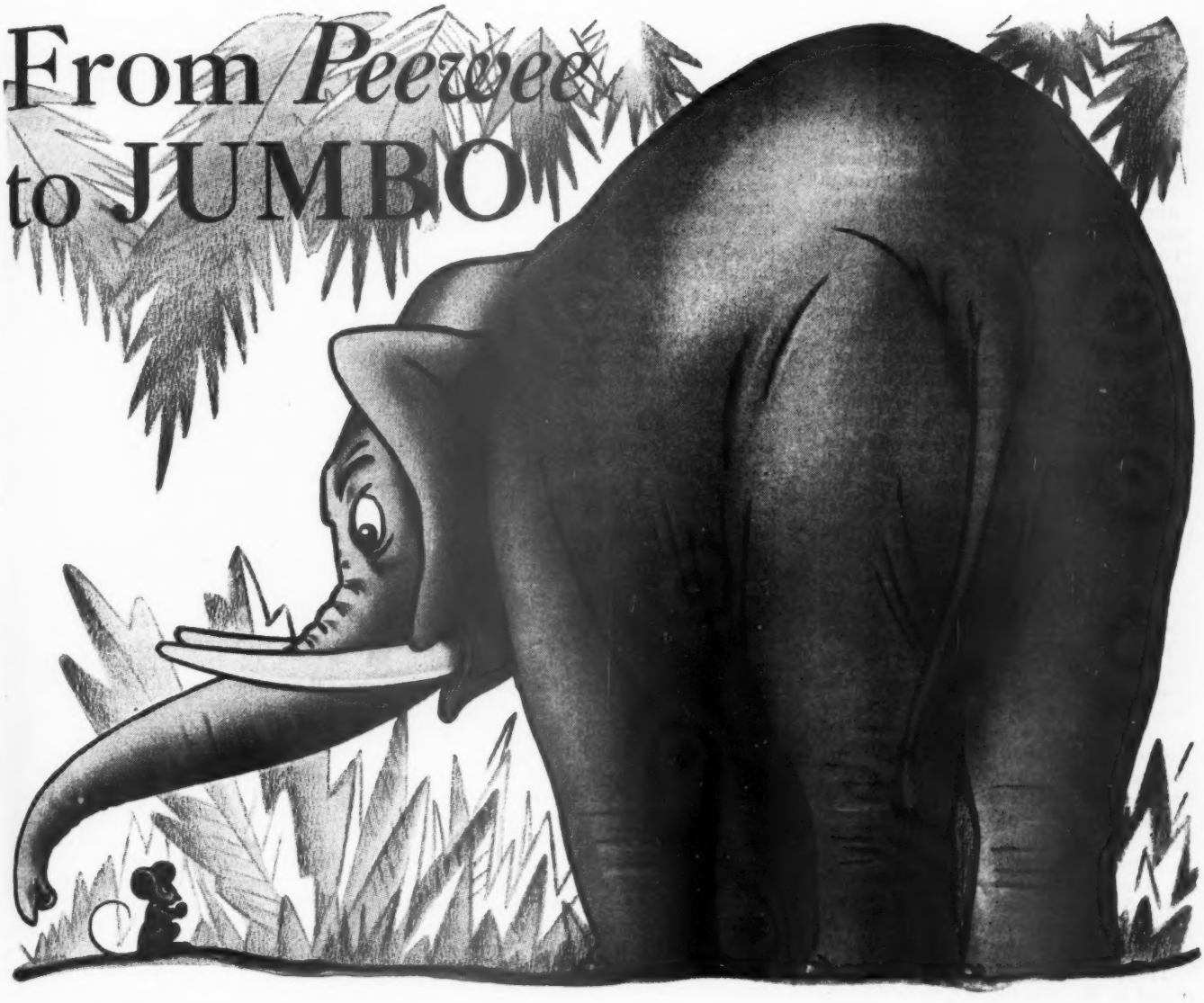
for metering the wet gas was to be incorporated by installing such meters in series on wet gas flow line.

Permission was obtained to use Katy Gas Field Unit No. 9 well (formerly Sweeney No. 1); Casing 5½ in. nom. O. D. 17 lb. Grade C set at 7398 ft. perforated 10 shots to the foot for 57 ft. from 7064-7121 ft. (4th zone); Tubing 2 in. E.U.E. 4.7 lb. swung at 7186 ft. D. L. Katz and W. F. Lowe met with the cooperating companies at the site on June 16 and 17, and we hoped to be able to start work with at least two small scale separators or equilibrium cells before the end of July. But the first week in August saw another meeting at the site at which D. L. Katz laid out the equipment in detail. However, it became necessary to use D. L. Katz and other assistance engaged for testing to help complete the installation of full scale equipment from August 18 to September 3, 1943, when the first run was made with only one equilibrium cell, which had been designed to handle about 150 st. cu. ft. per hr.

From September 3 to 17, various line samplers and tips were tested in cooperation with engineers equipped with special test cars to make tests of high pressure wells. We were then forced to shut down and postpone work due to a threatened hurricane until October 2. At that time we had the use of a second equilibrium cell of greater capacity. Work progressed steadily but slowly until October 28 when we were shut down due to the fact that all available stock tanks were full to overflowing, condensate could not be moved, and the Katy plant could not take the total gas production.

It was apparent that some time would be required to empty the tanks, which could be best used to correlate the data already accumulated as a guide to further work. It was expected that this could be done in a few weeks. But the data were confusing and about five months of night work sandwiched in between the demands of a large body of army, navy, and civilian students, were necessary to evaluate correctly the many variables involved. Any further effort or funds expended in additional work at Katy during this period of confusion were clearly inadvisable as it would not yield the results that should be expected and would therefore represent largely waste effort. It was early in May before we were satisfied that all significant variables had

From *Peewee* to JUMBO



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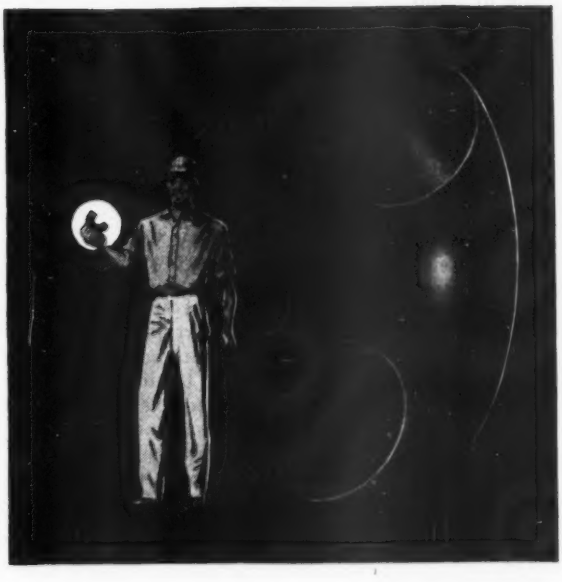

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been identified and correlated on a sound basis.

The full scale equipment. Fig. 1 is an isometric flow diagram showing the general arrangement of the full scale equipment. The well produced through either or both tubing and casing flows into line marked "from well." If valve H is closed and valve R open the well stream flows directly through the 3-in. line into the vertical loop as indicated. Valve E is closed under these conditions. A sampling tip and tube inserted through the "vertical sampling connection V" provides for vertical sampling. The vertical meter run is built into the down flowing leg of the vertical loop as indicated at I and followed by the horizontal meter J. There is then provided a bypass with "connections for line sampling" wherein various line samplers or small horizontal pipe sections could be inserted for the sampling procedures. Following this is a tee with a cock "P" for "horizontal stream sampling" by insertion of a tip similar to that used at the vertical sampling connection V. The wet gas then passes through the choke K into the separator M wherein the rate of accumulation of liquid as shown on the gage glass is measured by a stopwatch. The dry gas passes overhead from separator M through a choke and is metered in the dry gas meter L before flowing to the "plant line," "separators and stock tanks" or "vent line" as the case might be. The liquid may be discharged from the lower part of the separator through valve N and similarly disposed. Water could be drained from the bottom of separator M by valve line O.

The full scale gal. per min. are obtained by dividing the rate of accumulation of liquid in gallons in separator M by the rate of dry gas flowing from separator M through meter L.

When it is desired to test a wet gas stream of liquid content other than supplied by the well directly, use is made of the high pressure separator A and, if desired, the liquid accumulator S. Valve R is then closed with valve H open admitting the entire well stream to the high pressure separator A which is operated at substantially the same pressure as the sampling and metering section V.I.J.P. The gas leaves the top of separator through the 4-in. line carrying the meter D and leading directly through the valve E, which is now open, to the sampling section. If it is desired to send less gas through the sample section than is supplied by the well, this excess gas may be bypassed through choke B through meter C to plant, vent, etc. In this manner a gas carrying no liquid may be passed through the sample and metering section.

Liquid from the lower part of separator A may be passed through valve F and meter G on the 2-in. line and so introduced into the gas coming from the top of the separator A just before valve E to provide varying liquid contents within narrow limits. If it is desired to increase the liquid content of the gas to the sampling and metering section to a greater extent, liquid may be accumulated in tank S over a period of time and discharged rapidly into the 2-in. line as may be desired. Since the pressure in tank S is equalized with pressure in separator A it was found convenient to keep valve F closed and pass all liquid from separator A into accumulator S and withdraw liquid from tank S directly into the 2 in. line when running rich mixtures. In order to get a rapid flow of liquid from tank S into the 4 in. line it was found necessary to place a small orifice in the meter flanges D in the 4-in. line to create a small pressure difference between separator A and tank S on one hand and downstream of D in the 4-in. line.

Excess liquid accumulation in separator A or accumulator S can be sent to the plant or stock tanks by opening valve U. Water can be withdrawn from separator A at will through the usual independent drain as indicated.

Vertical and horizontal metering of wet gas. The vertical and horizontal meter runs were construed of Schedule 120, 4-in. pipe, actual calipered I.D. 3.437 in., and equipped with 2-in. orifice plates. They constituted part of the flow line of the sampling section. The ring joint flanges were carefully ground on the inside after welding to the pipe.

The vertical run consisted of a straight vertical upstream length of 64 in. for the 2-in. loop and 70 in. for the 4-in. loop measured from the center of the flange and a downstream straight length of 23¾ in. The horizontal run had straight sections of 83¼ in. upstream and 35 7/16 in. downstream measured between flange centers. No "calmers" or insertions of any kind were made in the pipe or meter runs.

In general no significant differences in the readings of the two meters could be observed when the differential recorders were operating properly. Horizontal seal pots were provided and liquid condensate of about 0.798 sp. gr. was placed in the seal pots. Quite frequently water would be observed to accumulate in the downstream pot of the vertical meter, or one or the other or both seal pots would show short of liquid. The vertical meter appeared somewhat more liable to these difficulties. Liquid accumulated both upstream and downstream of the horizontal meter as evident from trycocks in the bottom of the flanges.

The flow of gas was calculated by the equation:

St. cu. ft. (60°F. & 14.4 lb. per sq. in. abs.)

per hr. $= 889.2\ F_{GTZ} \quad \sqrt{h\,P}$

F_{GTZ} = meter factor interpolated from N.G.A.A. Tent. Standard, Proceedings 1942.

P = lb. per sq. in. abs. on meter

h = inches of water on recorder (as corrected)

889.2 is flange tap coefficient from cross plot with dia. of A.G.A. coefficient.

Seal pot factors were:

$$\sqrt{\frac{13.5 - 0.789}{13.5}} = 0.97$$

Temperatures were read from a calibrated mercury-in-glass thermometer in a well and pressures were checked against a calibrated Bourdon tube pressure gage on this line.

The gravities of the flowing stream of wet gas in the metering section were calculated from the known qualities and proportions of dry gas and liquid from separator M, which was operated at about 830 lb. per sq. in. and 100°F throughout the tests. The gravity of the dry gas from separator M was 0.64. The density of the liquid hydrocarbon in separator M was determined by a high pressure steel pycnometer filled directly from the separator, as 0.728 gm. per cc. at 820 lb. per sq. in. and 100°F. A molecular weight of 85.5 was computed for the separator liquid as estimated from equilibrium calculations. The gal. per min. were converted to lb. per M by multiplying by 6.07 and added to 48 lb. (the weight of 100 st. cu. ft. of dry gas of 0.64 gravity) to obtain the lb. total of dry gas plus liquid. The number of lb. mols of liquid was obtained by dividing the pounds of liquid by 85.5, the calculated molecular weight. This quotient was then added to 2.585 (the number of lb. mols in 1000 st. cu. ft. dry gas) to obtain the total lb. mols. The molecular weight of the total wet gas was then obtained by dividing the total pounds by the total lb. mols. The calculated gravity of the wet gas was obtained by dividing this molecular weight by 29, the molecular weight of air. This calculated gravity is thus equivalent to the gravity that would have been determined by an Acme Balance or similar device operating on a representative sample of the wet gas.

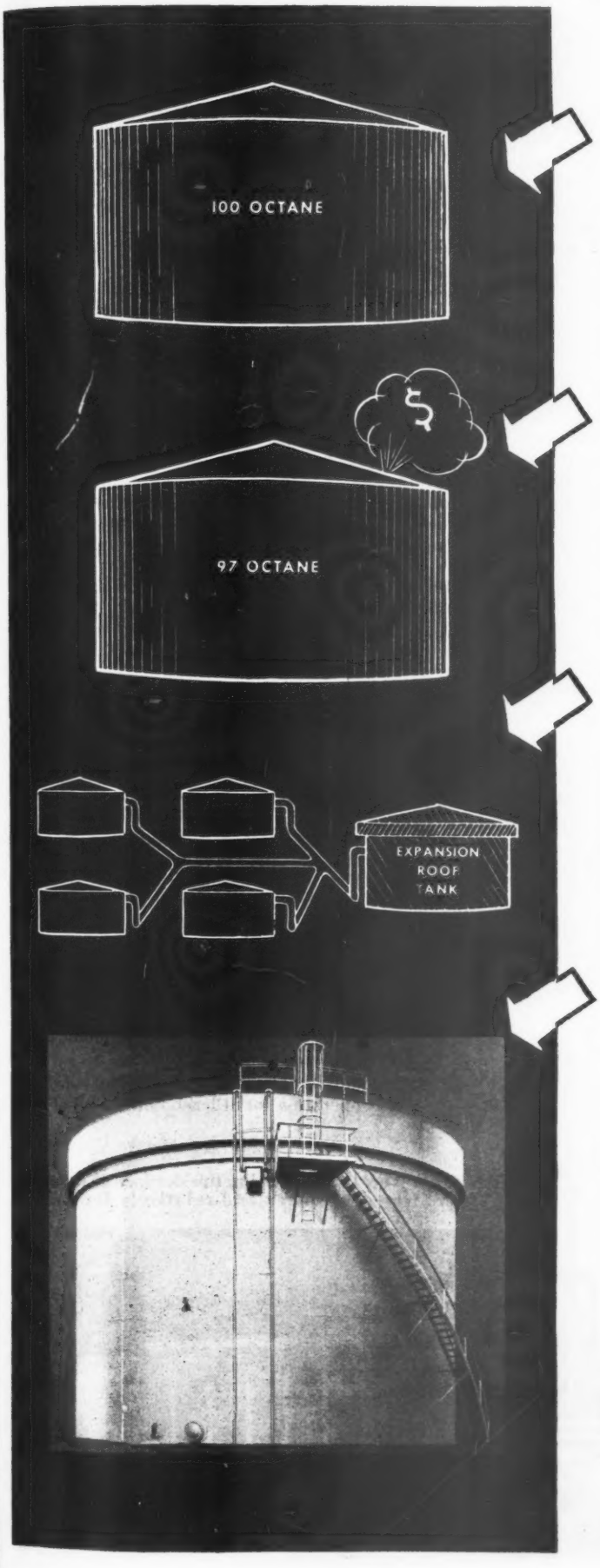
The correct total gas volume rate (dry gas plus equivalent gas volume of liquid) was computed by adding to the dry gas rate, 27.5 st. cu. ft. for each gallon of liquid accumulated in separator M since 1 gal. liquid when vaporized occupies

$$\frac{6.07}{85.5} \times 387 = 27.5 \text{ st. cu. ft.}$$

Up to about 2.5 gal. per min. in the meter run the error in the standard method of calculation does not exceed the limit of accuracy of the orifice meter. Under the conditions of use in these tests we had better luck with the horizontal meter; but no conclusions should be drawn from this work that either setting gives superior results to the other. Water content within the limits encountered in the tests (about 0.03 gal. per min. in well effluent at separator M conditions) appeared to have no significant effect. The error in this method may be due entirely to errors in the computed density of the two phase stream, which is computed as though it were all gas by means of the compressibility factor. In further work an effort will be made to use liquid densities for the liquid and gas densities for gas phases respectively to arrive at a correct composite density for the entire stream.

Sampling a wet gas at high pressure. If a sampling procedure is successful in

Facts about evaporation losses



A 10,000 barrel cone roof storage tank filled with 100 octane gasoline.

The same tank one year later. Change in temperature has caused breathing. During the daily expansion period, saturated vapors were expelled through relief valve—entirely lost. On this size tank it means 4% evaporation loss, or 16,800 gallons, as well as a three point drop in octane rating. Now the gasoline is only 97 octane.

This is a Graver Expansion Roof Tank manifolded to several cone roof tanks. As vapors expand they are forced into the Expansion Roof Tank. The roof rises, provides ample vapor space—holds all vapors—expels none. Result, no loss of gallonage—no lowering of octane rating.

A Graver Expansion Roof Tank, one of the many installed at refineries and pipeline terminals of the country's leading oil companies. Used either singly or manifolded to several cone roof tanks, this equipment is saving thousands of gallons of gasoline annually and maintaining its quality at the same time. Translated into dollars, this represents an enormous saving—one which can liquidate the original investment in a comparatively short time. Graver will be glad to show you how you can enjoy these same savings.

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withdrawing a small part of the entire stream that is representative of the total material flowing through the metering and sampling flow lines of the full scale plant, the gal. per min. indicated in a small scale separator or equilibrium cell operating on the sample line must be the same as the gal. per min. indicated in the full scale separator M when operated at the same temperatures and pressures. Furthermore, the composition of the gas phase is uniform and the composition of the liquid hydrocarbon phase is also uniform throughout the flowing stream at the point of sampling. Therefore if the gal. per min. is the same in the sample separator as in the full scale separator at the same conditions, it follows that the sample contains the same proportions of liquid and gas and is representative of the entire flowing stream. This principle is the basis upon which all sampling tests were made.

The sampling tube and tip were inserted in the sampling section in the vertical position at V, or horizontal position at P, or the line sampler in the horizontal bypass shown in Fig. 1. A copper tube from ⅛ in. to ¼ in. O. D. was used to connect the sampling tube or device to the sample separator. In some cases the sample was flashed through a needle valve into a coil in the same water bath as the separator and then discharged directly into the sample separator. But best results were obtained when the copper sample line led to a preheating coil in which the temperature of the sample was raised sufficiently above that of the separator so that the temperature upon adiabatic expansion to the desired pressure was the same as the desired temperature in the sample separator. This usually required a preheat of about 40° to 50°F. and not only eliminated hydrate difficulty but gave evidence of a quicker approach to equilibrium at the separator conditions.

As an indication of the accuracy of the sample, a correction factor was computed by dividing the gallons per minute determined in the full scale separator M by the gallons per minute indicated for the sample separator when both separators were operated at the same temperature and pressure.

The average linear velocity through the sampling tip divided by the average linear velocity through the sampling section at the point of sampling is called the velocity ratio and was found to be an important variable in all types of sampling. Usually a series of runs were made with all conditions the same except the velocity ratio so that the correction factor could be plotted as a function of the velocity ratio. If a method of sampling can be developed in which the velocity ratio giving the correct sample is always the same independent of the liquid content of the stream being sampled, the procedure can be made simple and reliable, as the other variables can be controlled.

The other variables, which were covered with varying degrees of thoroughness, include: Linear velocity or Reynolds' Number of stream in sampling section; design and diameter of sampling tip; distance of sampling point downstream and upstream from the nearest bend, fitting or obstruction in the flowing section; diameter of sampling section; position of sampling section (vertical or horizontal).

Line samplers were tested in a preliminary way at the beginning of the work. In all cases where results showed any promise, high pressure drops up to 200 lb. per sq. in. or more were observed. Their use did not eliminate any of the variables of straight tube sampling and did introduce other variables and complications. In view of the expressed desire to limit the pressure drop to as small a value as possible, no further work was done on the line samplers.

Sharp edged, streamlined tips designed to give a minimum of disturbance to the flowing stream, and blunt tips were screwed into a steel tube of ¼-in. I.D. and about 4 ft. in length, with a steel valve on the opposite end. The tip was centered in the pipe sampling section by means of a spider, either rigid or collapsible depending upon sampling conditions. The sample drawn through the tip and tube was conducted to the sample separator through copper tubing of from ⅛ to ¼-in. O.D. (wall thickness 0.035). In the case of the smallest tip of 0.07 in. I.D., which was formed directly on the end of a steel tube of that size, no valve was used and the tubing was directly connected to 25 ft. of ⅛-in. copper tube (0.055 in. I.D.)

The results include a mass of somewhat confusing data. But the following tentative conclusions are indicated by the limited data so far obtained on straight plain tube sampling with a centrally located sample tip.

1. The correct velocity ratio (average linear velocity in the pipe sampling section) is always less than unity if the stream contains any liquid.

2. It appears that thin-walled sharp tips may give a representative sample if used at a constant velocity ratio of about 0.94 at liquid contents from zero to well in excess of 10 per cent by volume (6.62 gal. per min. at 1500 lb. per sq. in.) in either horizontal or vertical sample lines provided there is a minimum straight section of about 40 diameters in length upstream of the tip and about 15 diameters downstream, and the velocity in the sampling section is sufficient to develop the required degree of turbulence.

3. The higher the pressure at which sampling is done the greater is the tolerance permitted in departing from these operating conditions.

4. Blunt or thick-walled tips introduce greater disturbances in the flow stream and therefore exhibit less tolerance to variations in operating conditions and also require a lower velocity ratio in sampling particularly as the liquid in the sampling section increases above 1.0 gal. per min. and are therefore considered less desirable than the sharp thin-walled tips.

5. The sample separator should be of generous capacity both as to gas flow and liquid accumulation to permit steady operation for at least 5 min. with at least

Fig. 9. Testing cells and auxiliary equipment. Large capacity cell on left was constructed by Garman O. Kimmell, Black, Sivalls and Bryson Company, and the one on the right on the scaffold by Stanolind Oil and Gas Company. Equipment in center foreground is a water heater and boiler.

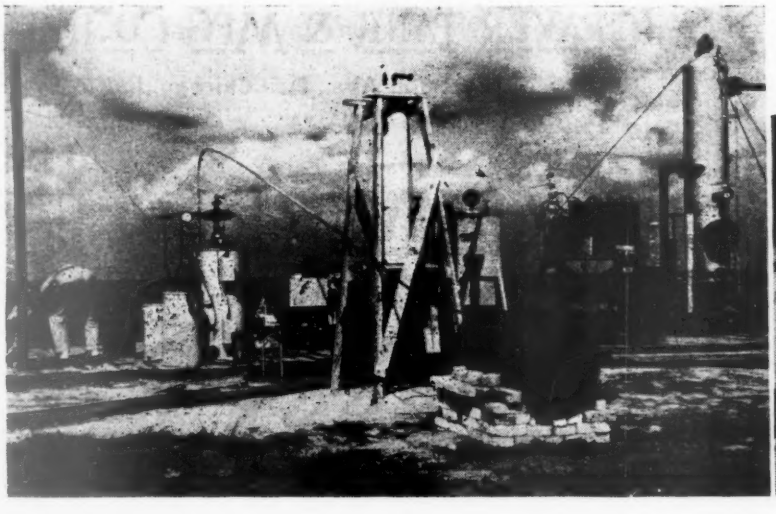
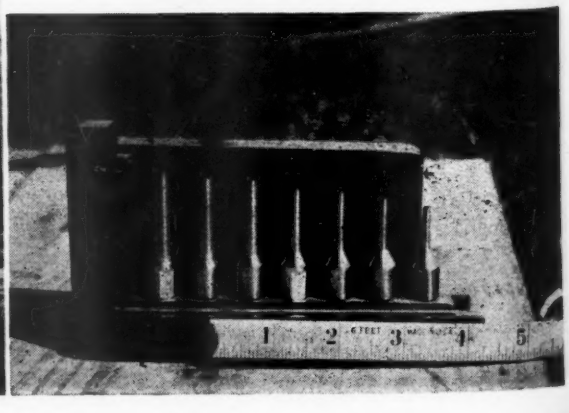
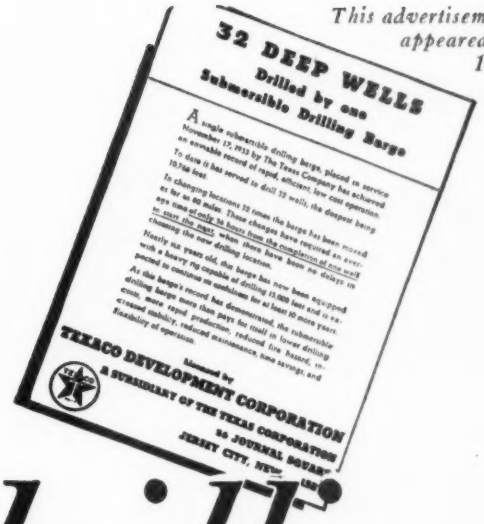


Fig. 10. The testing tips used. Note the sharp leading edges and relatively long taper.



This advertisement appeared in 1939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First Submersible Drilling Barge is 11 Years Old

Eleven years old and still going strong, the first Texaco Submersible Drilling Barge now has 54 wells to its credit.

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Today Submersible Drilling Barges are in the service of leading oil companies and contractors. We are proud of their part in expediting the production of more oil to aid in the war effort.

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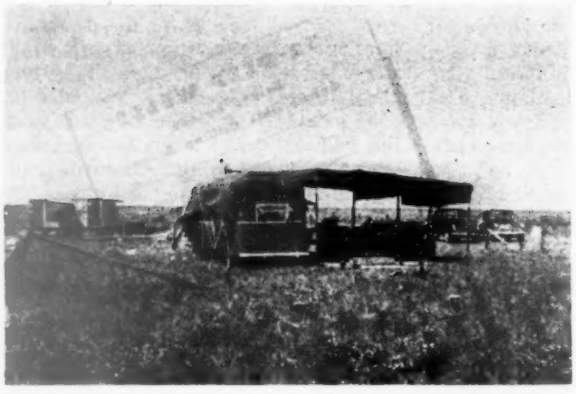


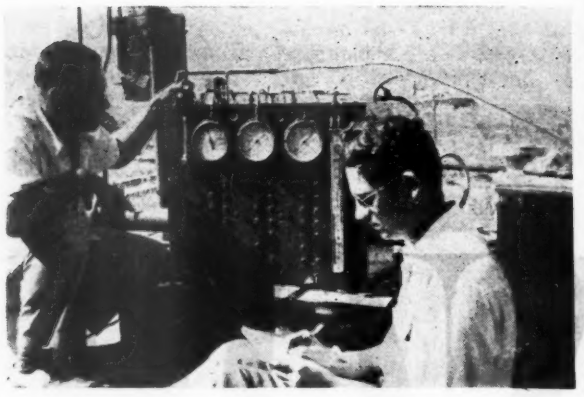


Fig. 11. Top left, trailer used as office and instrument storehouse, testing equipment in background.

Fig. 12. Bottom left, correlating data under the tarpaulin at the trailer, G. O. Kimmell and Dr. Don Katz.

Fig. 13. Above, front of the Stanolind testing cell with Carl Mantzel of that company on the left and M. J. Rzasa, University of Michigan, on right.

two readings, preferably more, of the rate of liquid accumulation. The sample stream should be conducted to the separator through a tube of the smallest consistent internal diameter and preheated so that when throttled it will expand down to the pressure and temperature of the sample separator.

▶ **Discussions.** The observed results summarized herein can be explained on the basis of the known properties of fluids in flow and a few assumptions that are probably not far from the truth. In turbulent flow it is recognized that the average velocity is about 0.8 that of the maximum at the center of the pipe. Therefore if we wished to remove a sample from the center of the stream through a tip whose walls had zero thickness so as to create the least disturbance to the stream, the average velocity in the tip would be the same as the average velocity of the stream at the center or $1/0.8 = 1.25$ times the average velocity throughout the cross-section of the pipe. If the liquid phase were uniformly distributed throughout the flowing stream such a sample would be representative of the entire stream.

A fair assumption as to the distribution of the liquid is that it is distributed throughout the cross-section inversely as the velocity through the cross-section. If this be the case, the sample taken from the center will not be representative of the entire stream but will be lean in liquid containing on the average about 0.8 of the proportion of liquid that it should contain to be representative of the entire stream. Therefore if the gas flow is retarded to 0.8 of its flow at the center or $1.25 \times 0.8 = 1.0$ times the average linear velocity, and the liquid continues entering the tip at about the same velocity as it has at the center of the pipe, as it should being the dispersed discontinuous phase of greater density, the sample so withdrawn would be representative of the entire stream.

Actually it is impossible to use a tip whose walls have zero thickness. Therefore the walls of the tip will introduce eddies and interfere with the flow lines of the fluids in the sampling section at the tip and the tip may be said to have a coefficient of intake similar to the coefficient of discharge of a nozzle. The least disturbance to the stream would be caused by a particular tip when the average velocity through the tip computed on its total cross-section is multiplied by the coefficient of intake.

For a sharp tip of thin walls this coefficient will be nearer unity than for any tip of heavier walls. Furthermore, there is probably some retardation to the flow of the dispersed liquid phase even with moderate retardation of the gas flow entering the tip. These two effects combine to make the correct velocity ratio less than unity, such as 0.94 for the sharp tips used in these tests. With tips of heavier walls there is more disturbance to the flow of the fluids, the coefficient is smaller, and the flow of liquid is affected to a greater degree as well as the flow of gas. This calls for a further retardation of the gas stream in the tip as the liquid in the flowing stream increases, to obtain the desired enrichment of the sample.

If the flow through the tip is greatly retarded the disturbance to the flow in the main pipe is increased with further effect on the liquid phase until erratic, or at least irregular, results are obtained at low velocity ratios.

If the flow through the tip is intermittent there may be a tendency for the liquid phase to accumulate in the sample tip and copper tube, tending to enrich the sample taken immediately after opening the line, as compared with samples taken continuously over a longer period such as a matter of minutes instead of seconds.

These characteristics appeared in many cases and all of these errors appear to be greater in the case of those tips that introduce the greater disturbance to the flow of the main stream.

▶ **Acknowledgments.** We wish to express our appreciation to all those who have contributed to this work; the members of the High Pressure Gas Division and others who contributed funds and equipment. We especially wish to thank Carl Mantzel of the Stanolind Oil and Gas Company, who was with us throughout the tests and gave generously of his time and effort; and G. O. Kimmell of Black, Sivalls & Bryson, Inc., who supplied equipment, ideas, time, and data; Professor V. Williams of Northwestern University; M. J. Rzasa, C. M. Sliepcevich, and Judson G. Brown of the University of Michigan assisted in the project.

Our thanks for the loan of equipment and for valuable advice goes also to numerous equipment firms. Among those which were particularly helpful were The Refinery Supply Company, Westcott and Gries, Inc., Hanlon-Waters, Inc., Pittsburgh Equitable Meter Company, Merco Nordstrom Valve Company, and the Moorlane Company. Without their generous cooperation in this difficult period some essential items of testing equipment would have been very difficult to obtain. ★★★

COMPANY'S TRAINING, HOUSING, RECREATIONAL PROGRAM SPEEDS BAHREIN REFINERY EXPANSION

By **JOHN H. KUNKEL,** *Refinery Editor*

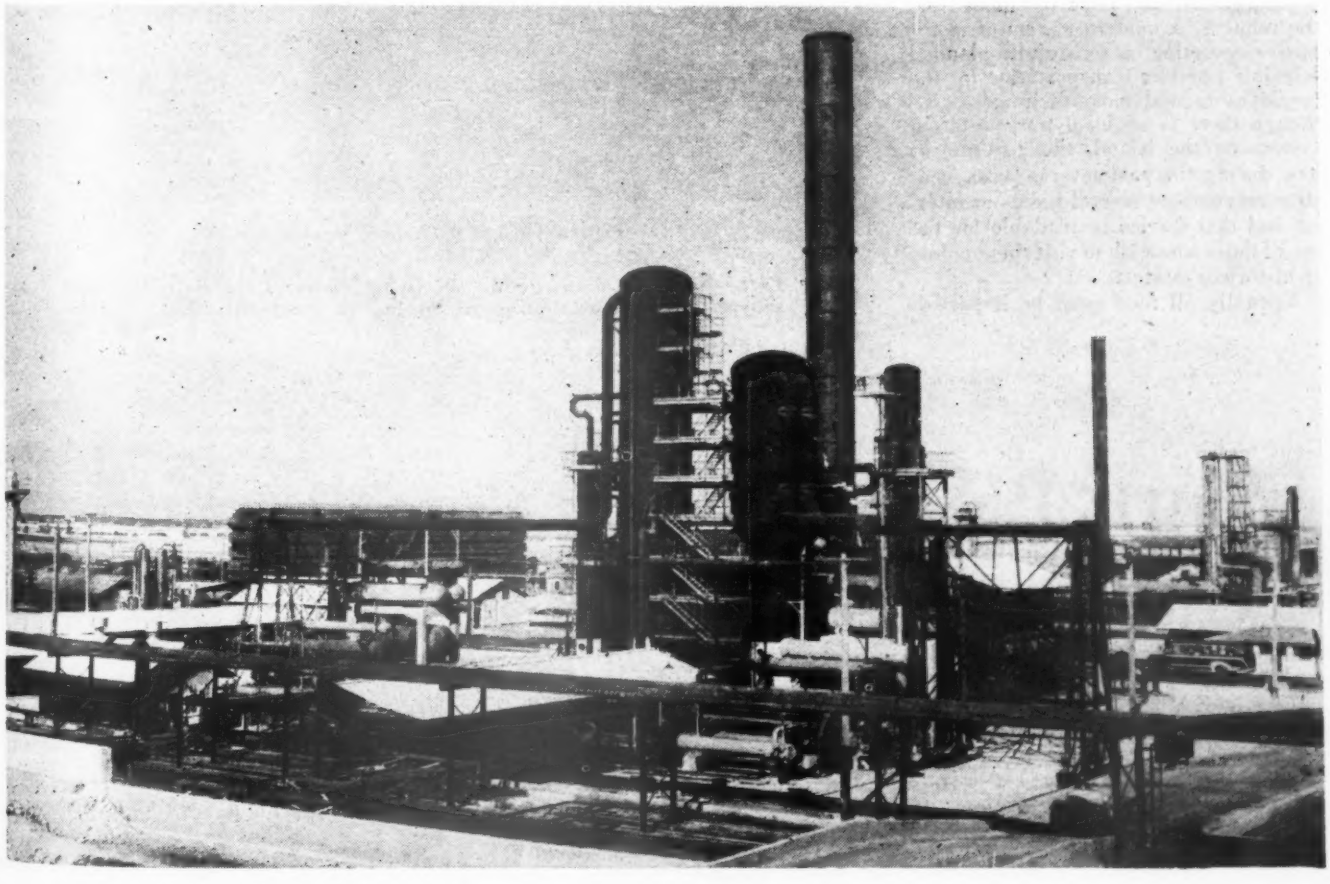
EXCLUSIVE BAHREIN ISLAND is the largest of a group of 10 islands situated off the eastern coast of Saudi Arabia, which comprise the independent Shaikhdom ruled by Shaikh Sir Suleiman bin Hamad al Khalifah. Through treaty relations, Bahrein is under the protection of the British Government.

The Bahrein Petroleum Company, Ltd., jointly owned by Standard Oil Company of California and The Texas Company, whose development of the petroleum resources at Bahrein Island constitutes an unusual chapter in petroleum history, is now in the process of expanding its refinery facilities on the island. Upon completion of the new facilities, the refinery will have a crude running capacity of 60,000 bbl. per day as compared to its present capacity of 33,500 bbl. per day. As a result of the expansion program, this small picturesque Arab Shaikhdom is the scene of tremendous activity at the present moment.

An expansion project of this magnitude, under present conditions imposed by war, presents many difficulties even for a site in the United States. In a location such as Bahrein Island, which is approximately 12,000 miles from the United States by present water routes, where all required materials must be imported mainly from the latter country, and where there is only a limited supply of local national labor available, practically all of which is totally unskilled, infinitely greater problems have been encountered both by the company's engineers and by Compania Constructora Bechtel-McCone S. A., who are acting as general contractors in charge of field construction. A simple illustration of the unusual nature of some of these problems is the fact that, with the opening of the pearl fishing season, which from time immemorial has been the main occupation of the Bahreinis, several thousand of the more skilled leave any employment that they may have and turn to the pearling fleets, each treasuring the hope that his dhow will strike an exceptionally rich haul—a hope that is but rarely realized.

Current expansion of facilities in the island plant off Saudi Arabia will almost double crude running capacity.

The limited supply of available Bahreini labor made it necessary that the contractor recruit, and send to Bahrein Island, a force of several hundred American journeymen in addition to the normal force of engineers and supervisors. This in turn necessitated the provision of housing, eating, medical, and recreational facilities for approximately 700 American construction employes, in ad-



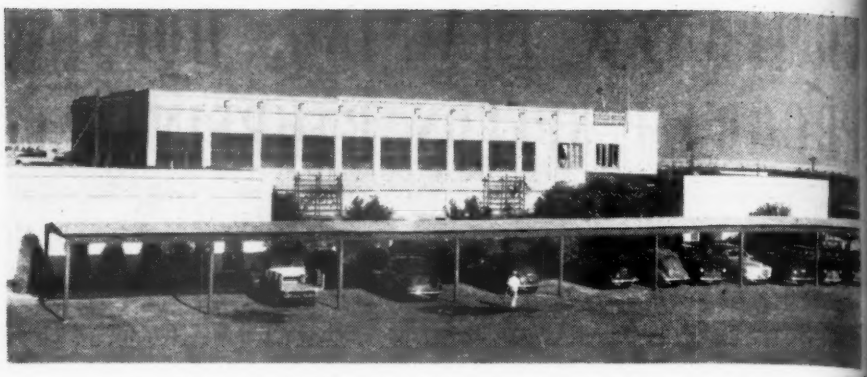
Bahrein Petroleum Company's modern 30,000 bbl. per day combination atmospheric and vacuum crude unit.

dition to the 500 British and Americans who comprise the operating force; for it can be readily understood that present producing and refining operations must be carried on at capacity during the period that the new facilities are being constructed.

Housing and recreational facilities. As the first step of the expansion program, provision of such facilities involved the construction of a small city consisting of modern insulated and air-conditioned housing, theater, hospital, school, clubhouse, and such outdoor facilities as swimming pools, golf course, cricket courts, football and baseball fields, tennis courts, and other recreational facilities. Provision of adequate recreational facilities is important because no other satisfactory means for utilization of employes' leisure time is available. Air-conditioning of the housing, messhall, theater, and clubhouse facilities was necessary from the viewpoints of maintaining efficiency of the American and British employes and the avoidance of excessive absenteeism, for the average daily atmospheric temperature during the five summer months approaches 110°F. with daily maxima as high as 120°F. Housing and recreational facilities were planned so that, after completion of the construction program, they will fit in with the general scheme of the company's residential area, which consists of air-conditioned housing for married employes and their families and air-conditioned individual quarters for bachelor employes.

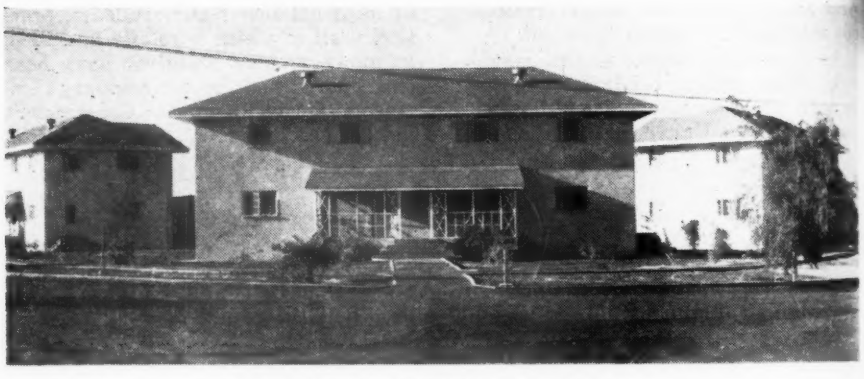
These new facilities are in the residential area, which is situated some distance from the shore on elevated ground adjoining the oil field and a few miles from the refinery. A modern system of motor busses operating on a carefully planned schedule provides transportation for the employes to and from their work. Although there is no local transportation system on the island, the government has, during the past several years, constructed roads to several points of interest and taxi service is available for the use of those who wish to visit these points of historical interest.

Virtually all food must be imported.



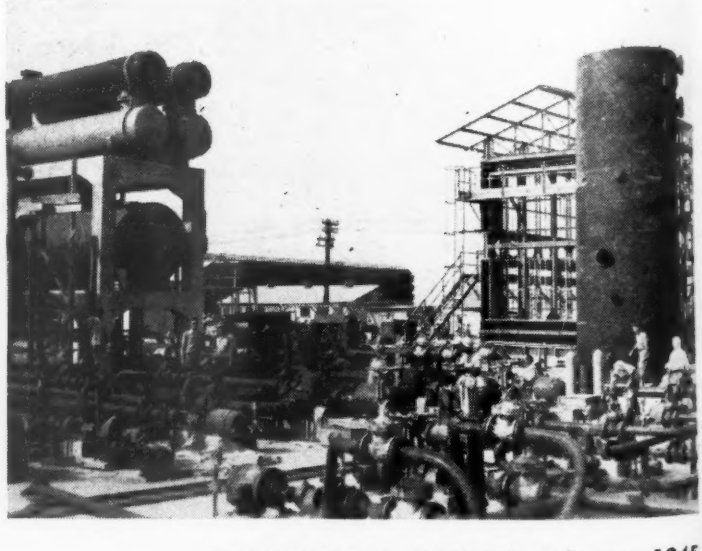
View of Bahrein Petroleum Company's new main office building.

Employes' clubhouse.



Typical view of bachelors' bunkhouse.

Left—Nationals constructing tile living quarters for Bahreini employes. *Right*—Installation of piping in crude distillation unit.



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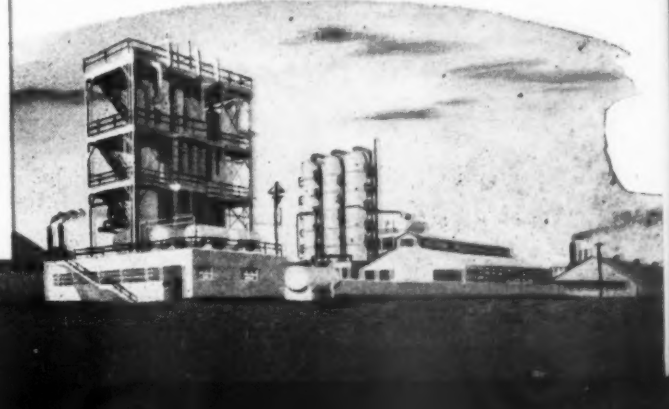


Frozen meats, powdered milk and eggs, canned fruits and vegetables, rice and other grains that are normally obtained in the area must at the present time be imported from the United States. Substantial quantities of fresh fruits and vegetables from neighboring supply points are seasonably available and with good supplies of fresh fish of finest quality available locally, a well-balanced diet is provided. All drinking water is distilled and piped to homes, offices, public buildings, and drinking fountains. Comfortable housing, good food, and adequate recreational facilities assist the British and Americans so far away from home and so unused to the tropical heat and humid climatic conditions in overcoming the pangs of homesickness.

During the period, while the new refining facilities are being constructed, present producing and refining facilities are being operated at capacity in a normal manner and a very high percentage of the finished production is being currently delivered to Allied Armed Forces in the Near East areas. Upon completion of the new refining facilities during the early part of 1945, substantial quantities of aviation gasoline as well as materially increased quantities of motor gasoline, kerosine, diesel and fuel oils will be available for the armed forces.

▸ **Social, educational, and training program.** Since the inception of its operations on the island, the company has shown great interest in the general welfare of its Bahreini and British Indian as well as its British and American employes. Permanent type housing has been provided for Bahreini and Indian employes, and a campaign of sanitation, mosquito control, and elimination of pests and diseases endemic to the area has been actively pursued with the result that there is at the present time comparatively little illness from these sources. From the beginning the company has conducted training courses for its local national employes and has assisted the local government in the operation of a technical trade school. Although the acquiring of a conversational knowledge of Arabic by company employes and the learning of some English by the Bahreinis has assisted to some extent in the training program, the media of illustration and demonstration are still the most effective means of conveying thoughts and ideas to the local nationals.

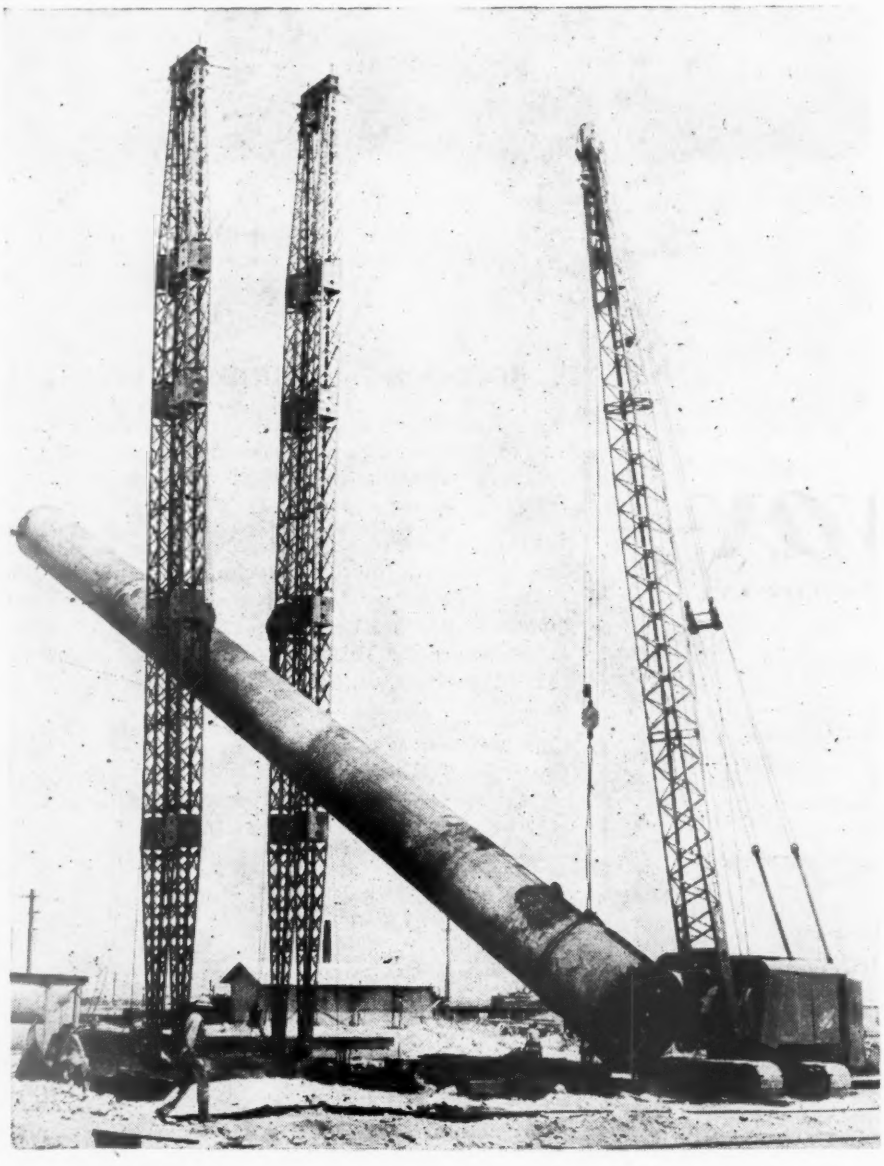
This can be clearly understood when one considers the background of these people who have for many generations depended for their livelihood on date growing, fishing, sheep and goat grazing, and pearl fishing and who, at the time of the company's entry into Bahrein, had no previous knowledge or experience in the use of the simplest types of modern tools commonly used in British and American industry.

That the company's efforts toward training its Bahreini employes have been successful is demonstrated by the development of a considerable number of refinery operators and craftsmen such as welders, pipe fitters, carpenters, truck drivers, and clerks. Development of these local employes plus the experience gained in carrying out the company's training program has been of enormous assistance in overcoming the almost insurmountable difficulties inherent in utilizing large numbers of untrained and inexperienced workmen, whose language and habits are different from ours, in carrying out a major construction program.

In view of the very limited supplies of fresh water available on the island, and the desire on the part of the company to avoid any action that might in any possible way jeopardize supplies from local wells for irrigation and domestic usage, salt water from the Persian Gulf is being utilized for condensing and cooling purposes. Due to the high temperature of the shallow water on the shoals surrounding the island, it was necessary to locate the intake several thousand feet off shore and considerable ingenuity was required in designing the intake conduit facilities so that a minimum of critical materials would be required from this country.

The company has had the active assistance and cooperation of Shaikh Sir Suleiman bin Hamad al Khalifah and the British political authorities, which has been a very great help in overcoming many of the more serious problems encountered in the field. This is but a continuation of the harmonious relationship that has existed from the beginning among Shaikh Sir Suleiman bin Hamad al Khalifah, his late father Sir Hamad bin Isa al Khalifah, the British political authorities, and the company's management, and is in large measure responsible for the unison with which the American, British, and Arab peoples are cooperating to effect earliest completion of the expansion program. ★★★

Raising isobutane tower at Bahrein.



Stars in oil business

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DETERMINING GAS FLOW BY USE OF CHART

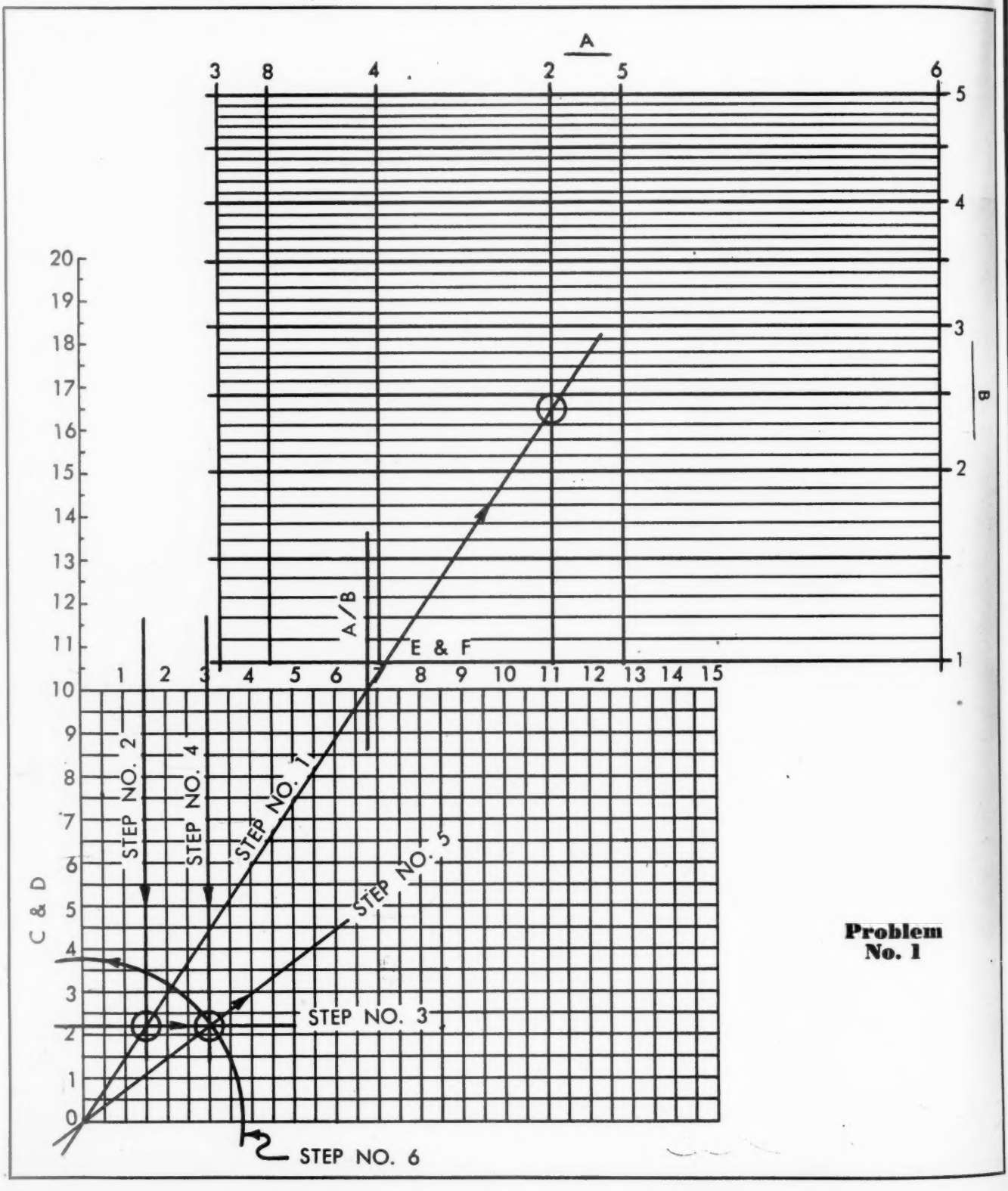
By **W. F. MARTIN**
Texoma Natural Gas Company

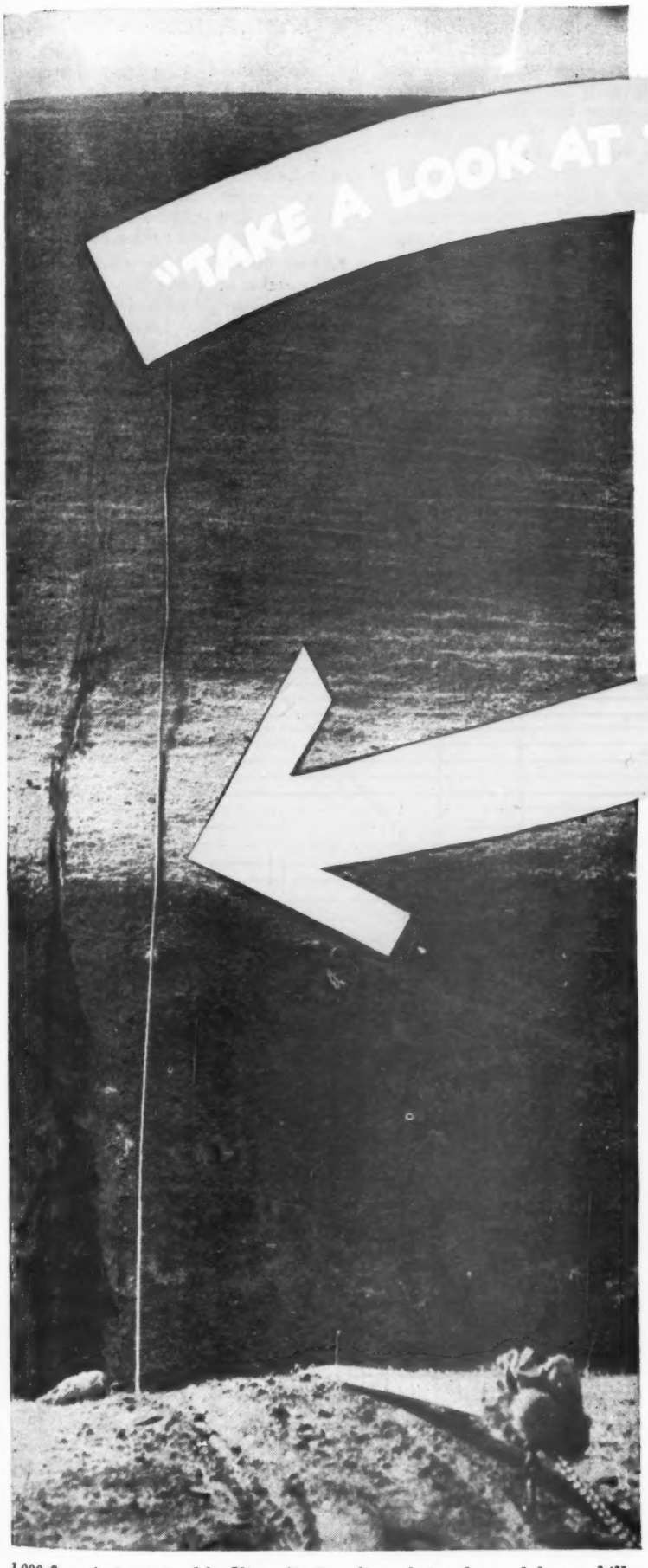
EXCLUSIVE THE accompanying chart is based on the formula:

$$Q = c\left[\frac{(P_1^2 - P_2^2)\,d^{5\frac{1}{3}}}{GTL_f}\right]^{\frac{1}{2}}$$

Q = volume of gas in M. cu. ft. on a 16.4-lb. pressure base per 24 hr.;
T = absolute flowing temperature of 60° F. + 460;
G = specific gravity of 0.700;
L_f = length of line in 1000 ft.

This article supplements the article on "Pipe Line Computing Charts," recently published in *The Petroleum Engi-*





1,000 feet of pipe joined by Victaulic Couplings, being dragged down a hill and across a ravine by light tractor-powered winch in high Sierra foothills.

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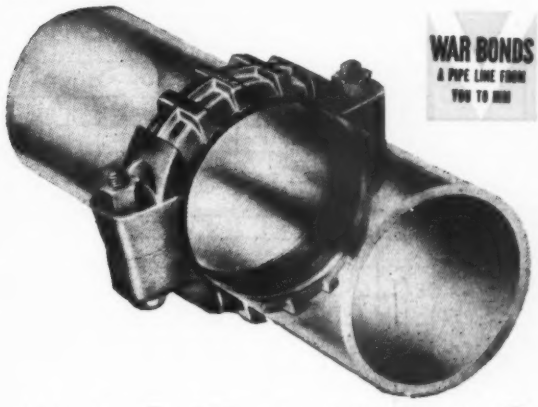
One thousand-foot lengths of joined pipe were dragged over hilly terrain at a single clip! Here is how it was done... The Western Oil Fields Supply Company moved 15,000 feet of 3″ pipe, towing it in 1,000-foot lengths! ... that means that as much as *50 sections of pipe remained coupled as they were dragged up and down hills, across ravines.* The strain on these couplings was terrific... strain from pull, plus strain from sag, as the line was drawn over a wide ravine... What couplings have the strength and flexibility to stand up against such a load? ... *The exclusive Victaulic Coupling.*

The Western Oil Fields Supply Company states ... "Our special ability is laying pipe across difficult terrain. We have over 50 miles of 2″ and 3″ pipe rented throughout California, laid across desert-like country, over treeless plains, up and down rugged hills. On every one of these pipelines we use Victaulic Couplings exclusively." Take a look at the advantages of the one and only genuine Victaulic Coupling, and you'll see why. We'll gladly send further details. Write Victaulic Company of America, 30 Rockefeller Plaza, New York 20, N. Y.



VICTAULIC

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SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

OIL MINING MARINE MUNICIPAL INDUSTRIAL

neer, where length of line was in miles.[1]

▶ **Chart construction.** The formula is rearranged thus:

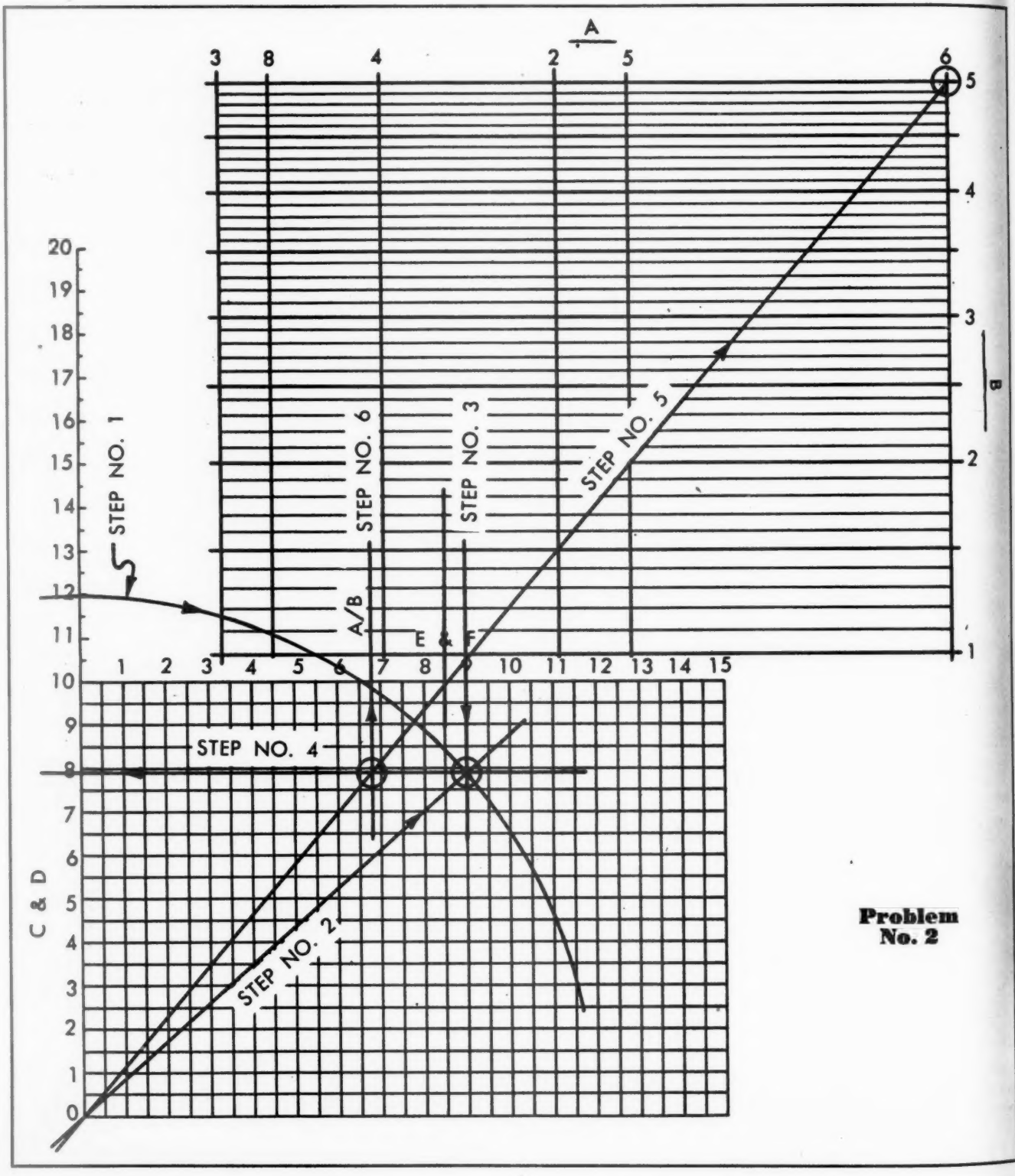
$$Q/c\left(\frac{d^{5\frac{1}{3}}}{GTL_f}\right)^{\frac{1}{2}} = (P_1^2 - P_2^2)^{\frac{1}{2}}.$$

From the above rearranged formula, it can be seen that two special scales are needed: One for $c(d^{5\frac{1}{3}})^{\frac{1}{2}}$ and another for $(GTL_f)^{\frac{1}{2}}$. The former is titled "A" and is the dividend scale; the latter is titled "B" and is the divisor scale. When constructing these scales, in order to locate them conveniently on the chart, $c(d^{5\frac{1}{3}})^{\frac{1}{2}}$ and $(GTL_f)^{\frac{1}{2}}$ may be reduced or increased so long as one is handled exactly as the other. In other words, each must have the same factor applied to it. This is, of course, obvious to one familiar with charts.

For brevity, clarity, and convenience, the writer has substituted letters in alphabetical order for certain values: $A = c(d^{5\frac{1}{3}})^{\frac{1}{2}}$ and is identified by pipe diameter; $B = (GTL_f)^{\frac{1}{2}}$ and is identified by line length; $C = (P_1^2 - P_2^2)^{\frac{1}{2}}$; $D = P_1$; E = volume of gas per 24 hr.; $F = P_2$, and L = center line of arm. E has different values for different sizes of line. For 2 in., the value is MM. cu. ft.; for 3 in., 4 in., 5 in., and 6 in., the value is 10 MM. cu. ft.; for 8 in., the value is 100 MM. cu. ft. Using these values of E, the scale value of C will be in hundreds. Should the pressures dealt with be read in less than hundreds, for instance, tens, then the above stated values for E would be divided by 10 to arrive at corrected values of E.

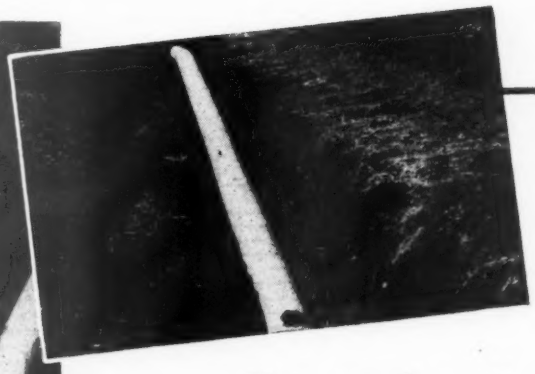
▶ **Chart operation.** By placing L at the intersection of A and B, we divide A by B. The quotient A/B is read on the E & F scale on the "10" horizontal line. The

[1] *The Petroleum Engineer*, October, 1944, page 191.



Problem No. 2

TEXAS GAS AIDS IN SERVING NEW YORK AND PENNSYLVANIA FOR THE FIRST TIME



New seamless pipe line link makes this possible

INDUSTRIES and homes of Pennsylvania and New York will be served with natural gas piped from Texas for the first time. This has been made possible by the construction of an important link from Wetzel, W. Va. to Clarion, Pa. supplementing the present supply of the Hope Natural Gas Company and The New York State Natural Gas Corporation.

The new connection consists of 145 miles of 12¾-inch O.D. NATIONAL Seamless Pipe. It is supplied with gas from the Hope system and the Tennessee Gas and Transmission Company's new line from Corpus Christi, Texas, to Cornwell, W. Va. The latter is one of the largest gas transmission systems constructed in recent years. It consists of 1180 miles of 24-inch and 85 miles of 20-inch pipe, a quantity of which is NATIONAL Seamless.

Today, engineers demand greatest overall efficiency. NATIONAL Seamless meets the needs of large diameter—high pressure—high strength ratio. Therefore, to specify NATIONAL Seamless is sound business.

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- Readily bent, cold or hot in the field
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- Seamless "Walls Without Welds"

●NATIONAL Seamless Pipe of 12¾-inch O.D. being laid for the 145-mile section of the natural gas line connecting the New York State and Hope lines with the Tennessee Gas & Transmission Co. line from Corpus Christi, Texas, to Cornwell, West Virginia.

UNITED STATES STEEL

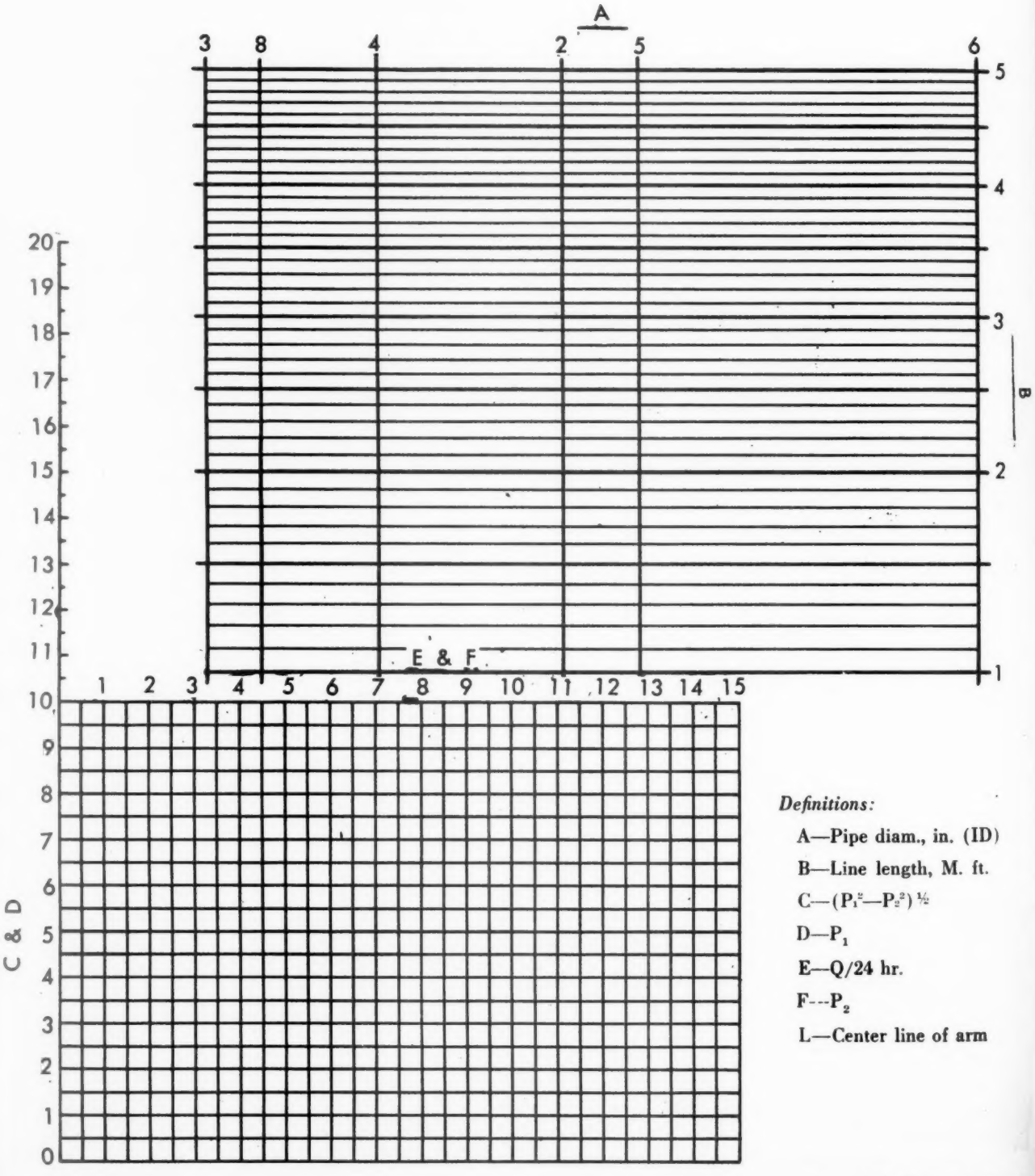
GAS FLOW CHART

Based on Weymouth's Formula

INSTRUCTIONS

Example: A — 2; B — 2.4; E — 1.5;
MM cu ft.: F — 300 lb.
Required: D
Procedure: Place L at intersection of A 2 and B 24; read C 225 where E 15 intersects L; move L to intersection of C 225 and F 300; mark L at this intersection; move L to vertical position and read D 375 at mark on L.

For 8 in., read E as 100 MM cu. ft.
For 3, 4, 5, and 6 in. read E as 10 MM cu. ft.
For 2 in. read E as MM cu. ft.
Basic conditions: P B 16.4 lb.
Base and flowing temperature, 60° F.
Gravity, 0.700.



Definitions:

A—Pipe diam., in. (ID)
B—Line length, M. ft.
C—$(P_1^2 - P_2^2)^{1/2}$
D—P_1
E—Q/24 hr.
F—P_2
L—Center line of arm

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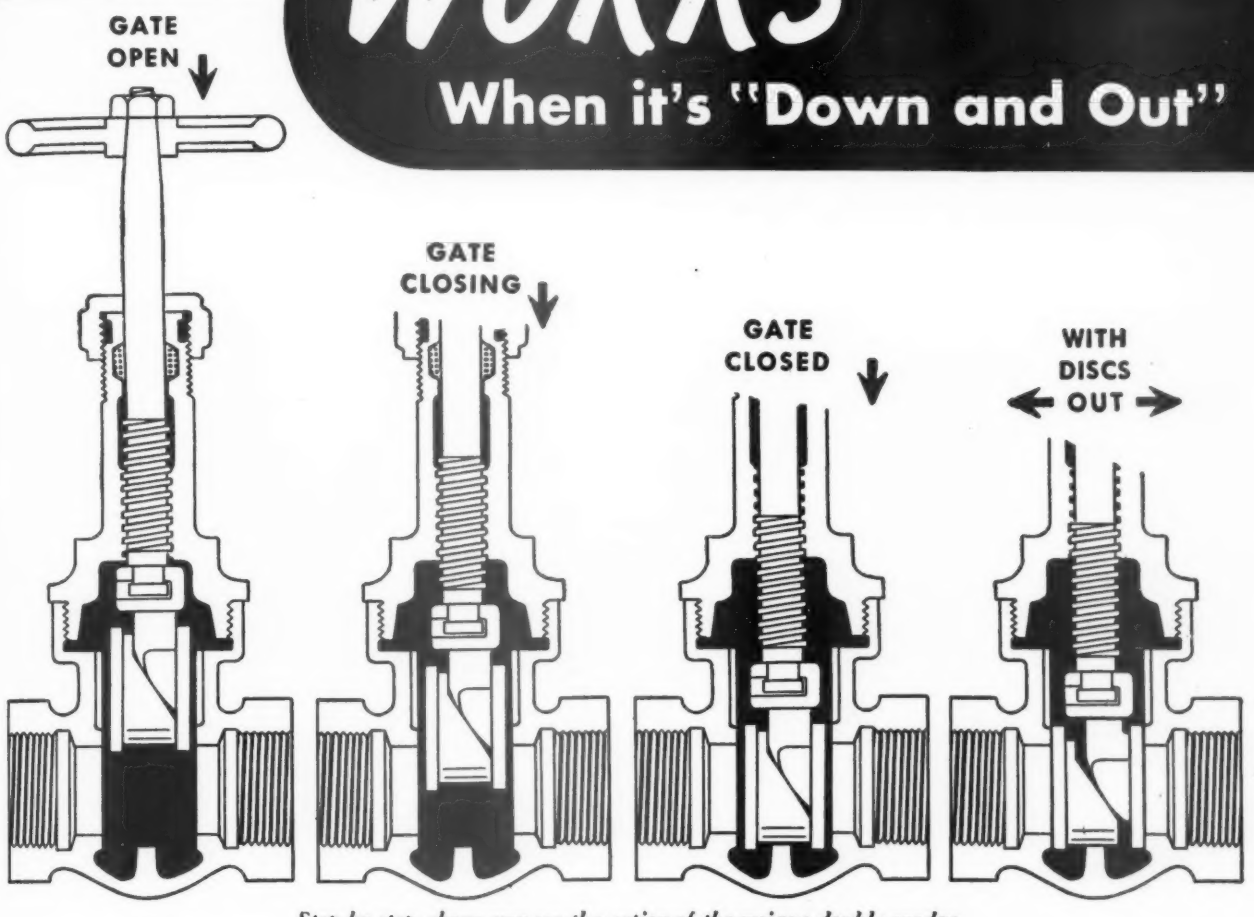
WORKS

When it's "Down and Out"



Step by step above, you see the action of the unique double-wedge and double-disc gate assembly as a Darling valve is closed.

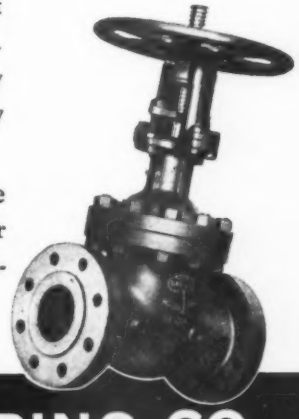
THERE'S nothing hard about making a valve. The bung in a barrel, the spigot in a wine keg, the baffle in a flue—they are all valves of a sort. The trick is to make a good one.

The Darling fully revolving double disc, parallel seat gate valve embodies a unique design that insures tight closing, easy operation and long life.

The Darling gate consists of only four parts, two discs, two wedges. In closing the Darling valve, the gate is lowered into the body until the discs are opposite the seats. There is no forcing to wear or gall seats and discs.

When the lower wedge contacts the bridge in the bottom of the body, the wedges begin to spread, and the discs are forced out against the valve seats. There is no tearing of metal against metal; discs simply go "down and out". They fit tightly. They wear evenly. They last for years. The valve is always easy to operate.

We'll be glad to give you complete information about Darling valves, or send you our 300-page, illustrated Catalog No. 17.



TRADE DARLING MARK

VALVE & MANUFACTURING CO.

WILLIAMSPORT, PA.

values of A/B are as follows when the stated values of E are used; that is, when the value of C is in hundreds:

For 2 in., units
For 3 in., 4 in., 5 in., and 6 in., tens
For 8 in., hundreds.

For example, take A = 6 and B = 5. When placing L on the intersection of A 6 and B 5, the quotient is 8.54. As 6 in. carries a value of tens, this quotient is read as 85.4. The value of E under these conditions is 10 MM. cu ft. Assuming an E of 50 MM. cu. ft., the 5 on the E scale represents this volume. It will be noted that E 5 intersects C 5.85 at L when L is held at intersection of A 6 and B 5. As C under these conditions is read in hundreds, C = 585.

As the formula used gives the volume of gas in M. cu. ft., the value of E, being 50 MM. cu. ft., becomes 50,000 M. cu. ft.

Summarizing, A/B = 85.4; E = 50,000, and C = 585.

50,000/85.4 =585 = C.

If pressures are read in less than hundreds; in tens for instance, then:

$$\frac{50{,}000}{10} / 85.4 = \frac{585}{10}$$

or

$$5{,}000/85.4 = 58.5 = C$$

▸ **Problems.**

Problem No. 1:

Given: Pipe diameter = 2 in; line length = 2.4 M. ft.; volume = 1.5 MM. cu. ft.; P_2 = 300.

Required: P_1.

Procedure: Place L at intersection of A 2 and B 2.4; follow E 1.5 to its intersection with L and note C 225 at this intersection. Move L to the intersection of C 225 and F 300. Length of L from zero to this intersection represents D. Mark L at this intersection, move L to vertical position and read D 375. P_1 = 375 lb. (The value of E is as stated herein, MM. cu. ft. because the value of C is in hundreds). See graphic solution.

Steps are numbered at lines.

Problem No. 2:

Given: Pipe diameter = 6 in.; line length = 5 M. ft.; P_1 = 120 lb.; P_2 = 90 lb.

Required: volume of gas per 24 hr.

Procedure: Place L in vertical position, mark it at D 120, reading scale as tens; move L to right until this mark intersects F 90. Note that C 79.4 intersects F 90 at this mark. Move L to the intersection of A 6 and B 5 and note that E 6.78 intersects C 79.4 at L. As 6 in. carries an E value of 10 MM. cu. ft. when C is read in hundreds, it will carry an E value of MM. cu. ft. in this case, for C is read in tens. E, therefore, is 6.78 MM. cu. ft. Volume of gas per 24 hr. = 6.78 MM. cu. ft., or 6780 M. cu. ft.

Note: Formula is based on M. cu. ft. A/B = 85.4; C = 79.4; E = 6780 M. cu. ft. (A/B)C = E. Substituting, we have 85.4 × 79.4 = 6780+.

See graphic solution.

Steps are numbered at lines.

▸ **Conclusion.** A really simple approach to computations by this chart is as follows:

First: Visualize a rectangle, the diagonal of which is the line drawn from zero to the intersection of A and B. If we let one side of this rectangle equal volume, the other side will equal $(P_1^2 - P_2^2)^{1/2}$. If the value of one side is known, the value of the other side is readily apparent.

Second: Visualize another rectangle where one side equals $(P_1^2 - P_2^2)^{1/2}$ and the other side equals P_2. The diagonal of this rectangle will equal P_1. With the values of the two sides of the rectangle known, the value of the diagonal is readily apparent; with the values of the diagonal and one side known, the value of the other side is readily apparent.

★★★

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The numerous crawler and wheel speed combination at the operator's command, in "CLEVELANDS," permit the application of tremendous power to the digging wheel when excavating through rocks and boulders as indicated in the illustration to left.

The picture at right shows a "CLEVELAND" digging through a frozen creek bottom and up a bank without a hitch, while digging at maximum depth. Such performance requires real ruggedness.

● "CLEVELAND" appreciating that of all construction equipment none must meet tougher assignments than the trencher designs and conditions its machines to meet the roughest going in any kind of soil or terrain. For instance; in "CLEVELANDS" double-strength steel is normally used in frame, boom and buckets and the toughest, longest wearing materials are used throughout—all driving sprockets and segments of the digging wheel are of heat-treated drop forged alloy steel. Wide tread and low ground pressure, all gears in grease sealed housing and a preponderance of anti-friction bearings assure strength, endurance and stability. In fact from the husky Gasoline or Diesel power plant to the high-capacity digging wheel you will find in "CLEVELAND" a toughness, a freedom from friction and a protection from wear to an unsurpassed degree.

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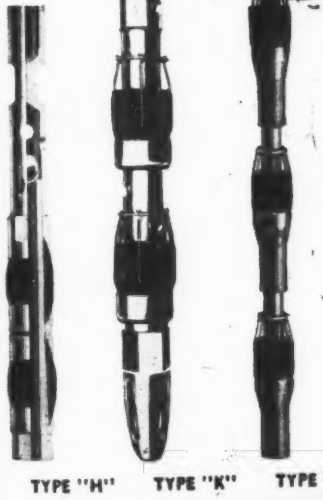

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SAFE PRACTICES IN ROTARY DRILLING

By **DON ATTAWAY**, Arkansas Fuel Oil Company
Safety Engineer

EXCLUSIVE THE knowledge of safe drilling operations and procedure has been largely developed by the trial and error methods of drillers who passed their experience and information on to members of their crew. These men eventually developed into drillers and most of them taught or practiced the procedures they had learned.

This method of passing on safe operation procedures, however, has not been complete nor has it acted favorably upon the drilling accident records, for this operation has constantly reported the greatest injury figure in the petroleum industry. Since 1940, the drilling accident frequency has mounted year by year, rising from 40.30 in 1940 to its present peak of 53.99. Reports from the U. S. Bureau of Mines for 1942 show a frequency of 52.74 accidents per million man-hours worked. The American Petroleum Institute for 1943 reports a frequency of 53.99 and the National Safety Council for their contest year 1943-44 records a frequency of 47.70. These high figures can be compared with the overall rate for the petroleum industry, which ranges from 11.72 to 18.72 for all operations.

The purpose of this article, therefore, is to summarize from the experience of drillers, safety engineers, geologists, production foremen, and drilling crew members the safe practices that will make it possible for new workers to avoid mistakes that could cause serious injury as well as costly property damage. Such practices and procedures are those most generally accepted among various company and organization safety rules, codes, and regulations. They are not to be confused, however, with federal, state, or insurance laws and regulations.

Drilling hazards. The hazards of drilling operations range from fire and explosion to falls and bruises. Among the fatal accidents recorded last year are blowouts, boiler explosions, dropped casing, falls from derricks, loose cables, fallen crown blocks, and center boards. Few perils to human life are missing from the drilling business. One drilling company compiled 179 different hazards and conditions that contributed to 3450 accidents on rigs over a 5-year period. These accidents did not just happen. They were caused by known agencies.

Qualifications of drilling crews. The driller is the key man of the crew. He should be physically fit and properly instructed in safety measures. A driller with unsafe habits causes his men to follow unsafe practices and injuries result. The driller is usually in the most protected position on the rig and can take desperate chances without much danger to himself, but such practice exposes his men to injury or death. A driller with poor eyesight or hearing is dangerous. The driller is charged with running the rig and inexperienced crew members must be kept away from the controls.

The crew members should be physically fit men. The derrickman must be agile and strong. The boiler foreman must be an experienced and capable man with full knowledge of steam generating equipment. The idea that any man can operate boilers is a fallacy that has cost dearly in human lives.

A summary of the experience of drilling operators and crews in preventing accidents on the job.

Rigging up. Many injuries occur during rigging up. The entire crew must consider all the possible hazards of the location. Swamps and lowlands usually aggravate slips and falls and often such locations are inhabited by snakes and venomous insects.

During the erection of equipment, care and foresight are demanded and supervision must be delegated to the proper man or men to insure organization and team work. Lines must be securely hooked to equipment. Heavy timbers, shafts, and such must be handled cautiously.

Installing boilers and piping. If local laws permit, boilers should not be set closer than 200 ft. to the derrick. Terrain sometimes reduces this distance to 150 ft., but, in any case, the boilers should be on the downwind side of the derrick and installed so that neither end of the boilers points toward the derrick. In gassy territory, the boiler distance should be considerably increased. (See API Code No. 2—Oil Field Boilers).

Only high pressure "steam" fittings should be used. Fittings, water and steam lines on the boiler installation must comply with ASME and state boiler rules and regulations. Many boiler accidents are due to inexperienced persons using incorrect fittings and piping on boiler installations.

Fuel controls, storage tanks, and flammable liquid containers must be kept away from the fire box opening and out of line of "flash-backs."

Dog houses and tool sheds should never be placed in front or back of the boilers.

Blowoff lines must be straight and well anchored with a separate line for each boiler, so situated that workers will not be burned by steam. Each boiler should be blown down once each tour or more often if water conditions are bad.

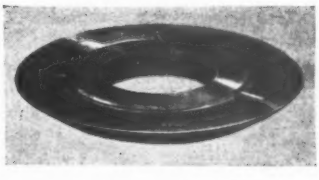
Boiler feed pumps should always take

Location hazards multiply when in swamps and lowlands. A safe and solid roadway to the rig reduces worker exposure.

WITH MISSION VALVES *you get* LONGER, UNINTERRUPTED PERFORMANCE

NEW VALVE INSERTS last at least twice as long as regular inserts

(COMPOUND 308)



Actual field runs show that Compound-308 Inserts last far longer than regular inserts in ordinary mud and many times longer than regular oil resisting inserts when hot, oily, or chemically treated mud is pumped.

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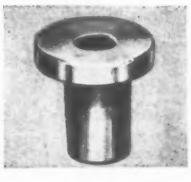

This low cost replaceable bushing takes the wear instead of the valve seat. Longer valve seat life results in less shut-down time and low replacement cost.

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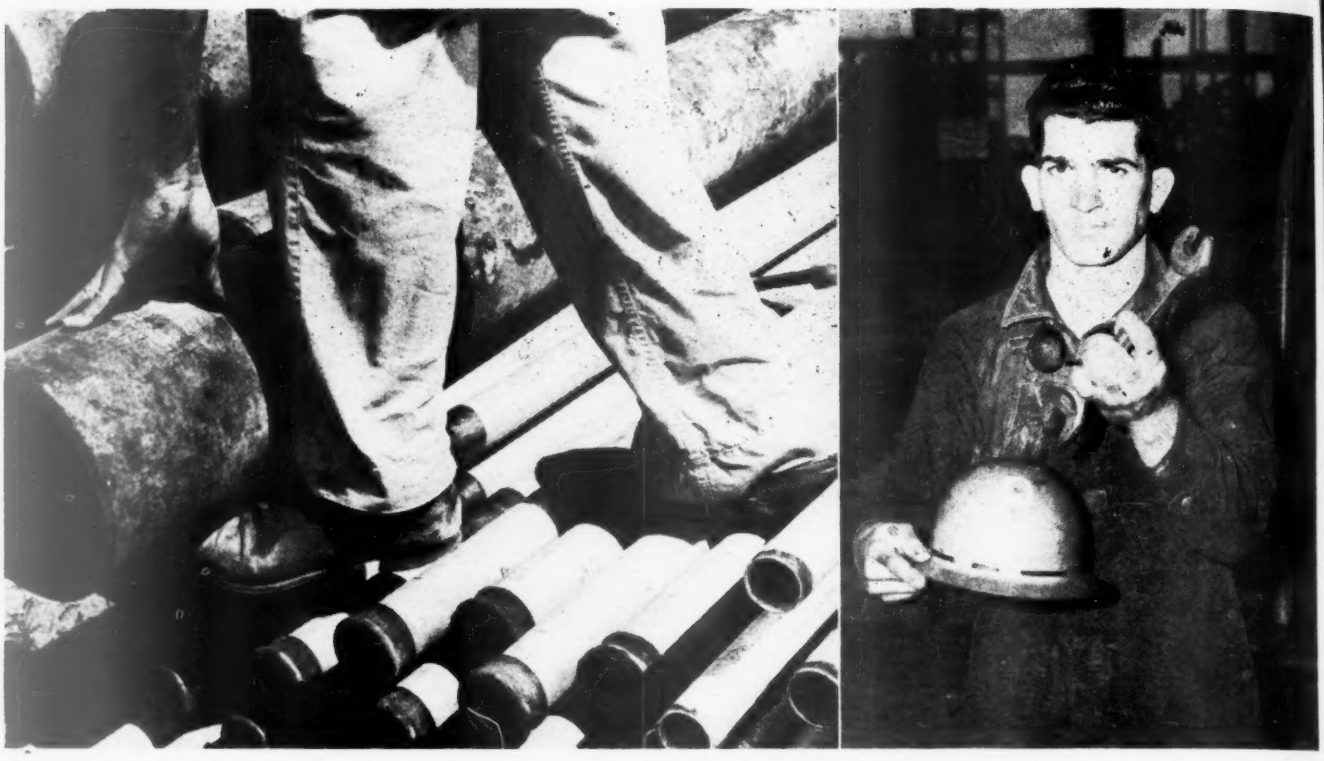


Left—**Foot injuries account for 13 per cent of drilling operation accidents. They usually result from pipe handling and falling objects.** *Right*—**Dropped wrenches, tools, and fittings account for 7 per cent of drilling rig accidents. This man's safety hat probably saved his life when he was struck on the head by a dropped wrench.**

suction from a storage tank or pit and never from a branch or main line.

Every boiler must be equipped with proper relief valves and these should have a wire or chain for testing at least once each tour.

Smoke stacks should be anchored securely by guy lines to posts set at least 6½ ft. aboveground. Guy lines should never be attached to steam, water, or fuel lines.

Exposed steam lines in working areas or near walks, ladders, or derrick floors should be insulated at all points of possible body contact.

Valves on steam lines should be painted red where water and steam converges into one discharge.

Steam must be turned into cold lines very slowly. Sudden pressure and expansion may rupture the line. When the line has warmed, the steam valve may be opened fully and the far end of the line opened slightly to drain water.

▸ **Pumps and engines.** More than half of the drilling engine throttles leak and bleeders should be placed between the cylinders to discharge escaped steam that might suddenly cause an engine to start while workmen are repairing chains or sprockets.

Only high pressure fittings in good order should be used for setting up pumps and a relief valve of approved type and capacity should be part of the discharge manifold.

The rotary clutch should be thrown out and the main valve on the steam manifold closed if the engine is shut down temporarily. If repairs are to be made, the bleeder should be opened.

Pump steam exhaust should be directed so that it cannot strike workmen.

Any pump shut down for a period of time accumulates water in the steam cylinder and this should be drained by means of cocks in the cylinder bottom, for the water may rupture the pump or be ejected with considerable force through the exhaust, when the pump is started.

During freezing weather, idle water pumps should be protected by draining.

Mud lines must be securely anchored to prevent pressure unscrewing the free end at an elbow or joint.

▸ **Derrick.** Rebuilt derricks may be weak or dangerous due to improper erection. Non-uniform bolts usually cause rig builders to discard lock washers. Such construction creates a serious hazard.

Drilling crew members should avoid the derrick floor until the rig builders are finished. Loose material left by the rig builders must be moved away before rigging begins.

The rat-hole casing should be installed at least 18 in. above the floor level.

The weight indication diaphragm should be secured to a derrick brace so that sudden shocks on the drilling line will not jerk it loose.

The rotary table opening in the derrick floor should be closed until the table is made ready to move in place.

All derricks, except API steel, must be guyed and the derrickman is responsible for seeing that the wires are tight.

The day crew on steel derricks should inspect the derrick for loose nuts, girts, and braces at least once every 15 days.

An approved safety belt must be worn by every man working above the derrick floor unless the platform is fully enclosed.

Never fasten chain hoists or snatch blocks to girts for rigging or operation.

Never slide down pipe or catline when coming out of the derrick.

Every derrick should be equipped with an emergency life line exit. This line should be at least one-half inch 6x7 galvanized cable and extend from first girt above working board to a tree or deadman at a pitch of at least 30 deg. A standard safety slide set to release with the weight of the workman must be mounted on the cable. The friction part of the slide should be of non-sparking metal. A 3-in. by 10-in. board should extend from platform past the handrail to facilitate the use of the slide.

Every derrickman must ride the slide once for a check, but it must not be used for regular descent.

Derrickmen must not start up the ladder until the first string of pipe has been pulled and set on slips.

While working the derrickman's tail rope to the safety belt should be anchored near a corner of the derrick with just enough slack for free moving. Many tail lines tied in the center of the girt have caused loose slack to be caught on the traveling block jerking derrickmen to their death.

Pipe standing in the derrick should be tied firmly so that wind cannot make it shift or throw undue strain on the derrick.

▸ **Ladders, walkways, steps, and platforms.** Derrick ladders must reach from derrick floor to crown and, unless of enclosed type, run in a straight line except where offset platforms are used.

The ladder should be on the side next to the driller.

When the derrick floor is more than 2 ft. aboveground, steps from the floor to ground must be provided at 2 or more places. These places are usually the exits to the boilers, steam pumps, and tool house.

If 4 or more steps are required, they must have handrails.

Walkways and steps should have toe boards and cleats to prevent accidents caused by slipping.

Working platforms should completely fill the space between the derrick leg and the girt and should be securely fastened with U-bolts attached to the cross-girts.

The fingerboard must be secured by a light cable to prevent it falling if struck by hook or traveling block.

Draw walks. The rotary drum should have a steel guard in front. All drive chains and sprockets should have guards securely installed.

Keys on shafts should be covered with metal thimbles and the cap screw should be counter-sunk.

In removing or installing drive chain pins, crew members must wear goggles.

Robishaw units should not be used in setting up or tearing down rigs.

Core barrel overshots not in use should be lowered into a joint of pipe sunk from the derrick floor.

Crown block. The crown block should be landed by the daylight crew. Multiple lines should be used to avoid overloading. Usually two lines are strung through the small block on the gin-pole and through the center sheave of the crown block and deadended at the gin-pole crosspiece.

The crown block shall be clamped to the water table. Gudgeon caps must be kept securely bolted so that sheaves will not jump out of bearings and fall.

The crown block should be taken down before swabbing.

Traveling block. The traveling block should be well guarded. The boom years taught drillers and crews that it does not pay to take chances with traveling blocks. Missing fingers, thumbs, and hands proved the point. Few modern drilling companies use an unguarded traveling block.

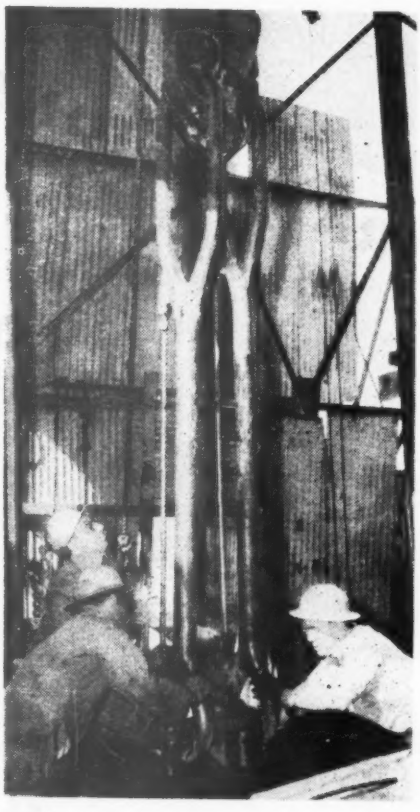
All traveling blocks should be strung and unstrung on the derrick floor.

The dead line should be strung next to the fourble board and the fast line should be away from the fourble board to give the derrickman clearance for guiding the block.

Suitable string-up chains and means for holding the traveling block should be provided while stringing.

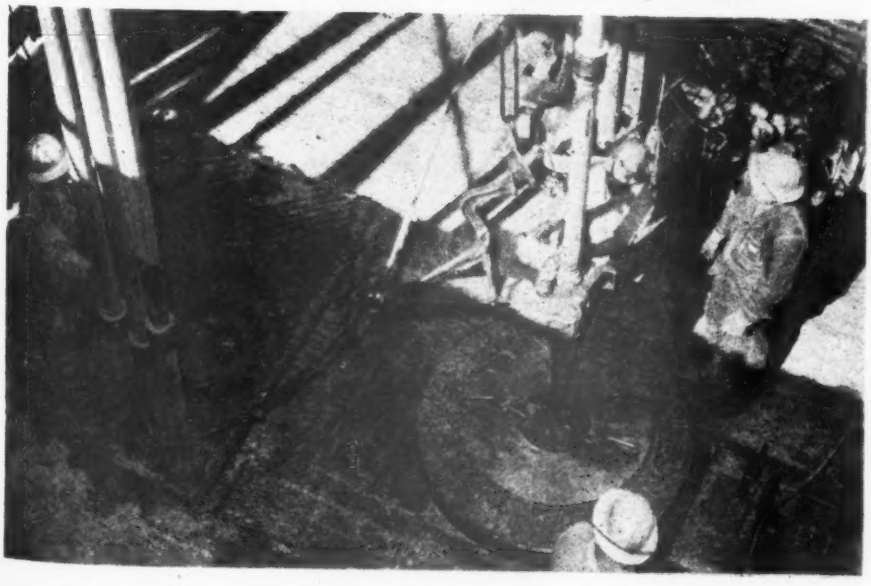
Every traveling block should have a safety housing with no square bolt heads or projections and slots or holes for cable passage to prevent workmen having their hands and fingers caught.

The dead-line anchor sheave must always have U-straps to keep the line from jumping out of the sheave.



***Above*—Floor crew in process of latching elevators. Observe hard hats are standard safety equipment. Note attention that floor man is giving to lines and traveling block and derrickman.**

***Below*—A safe drilling crew in correct position during operation. Note rope covered floor in pipe stand to prevent slippage. Breakout tongs are substantially snubbed and correctly installed.**



Snatch blocks and chain hoists. In setting up the rig, the chain hoist should be hung from the water table.

The hook of the snatch block should be closed into eye of the eye-bolt, which is bolted to tong sill.

Elevators, catheads, and catlines. The key seat and key on every cathead must be covered with a thimble. Grooved, worn, or damaged catheads must be replaced or repaired.

Every drill pipe or casing hook must be guarded to prevent the elevator or swivel bails from unhooking.

All elevators need ears on the handles to guard workmen's hands and should have at least 6-in. extensions on the handles.

The heavier the load to be lifted, the greater number of turns required on the cathead to raise the load. Often heavy loads burn the first turn of rope and later the rope will fail.

The catline should be used only on a slowly moving cathead and loads requiring less than 6 coils of line. Wire rope cannot be used as a catline. Badly frayed catlines must be replaced.

When not in use, ropes should be neatly coiled and placed out of the way.

Make-up posts. Star posts should have a bracket at the foot to prevent turning.

Star posts, stiff and back-up posts must fit snugly in the rotary hole.

Pipe racks. Boards must not be nailed on pipe rack walkways because protectors hang on them when pipe is brought in.

Racks must have a clear space with no obstructions. The top of the rack should be about truck bed height and the surface of the driveway for truck approach should be level and parallel to the rack.

Supports under the rack should be at least 10 in. by 12 in. and strongly cross-braced. The rack capacity should be such that no more than 3 tiers of 6-in. drill pipe or 4 tiers of 4-in. drill pipe need be placed on any one rack.

Pipe joints should be dragged into derrick one at a time.

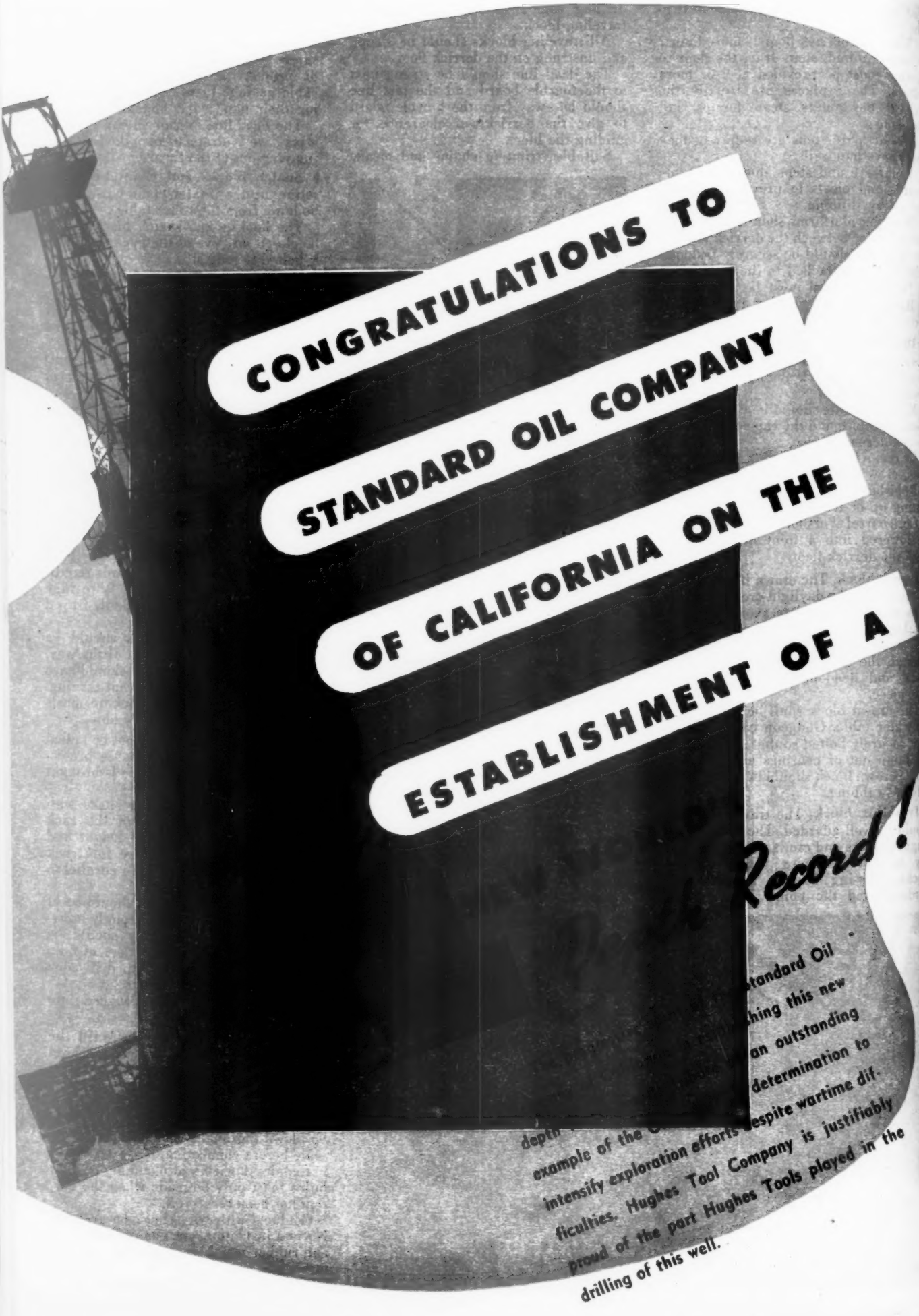
Lights. The generator should be placed 2 ft. or more above ground level to protect from rain and water and must be perfectly aligned and accessible for repairs.

The steam line to the generator should be blown thoroughly to remove dirt and scale before connecting.

Repairs to wiring or changing of light bulbs must only be made when the current has been turned off.

Contacts with wires must be avoided. Normal insulators, such as rope, boards, and rubber may become electric conductors while wet.

(Continued on Page 140)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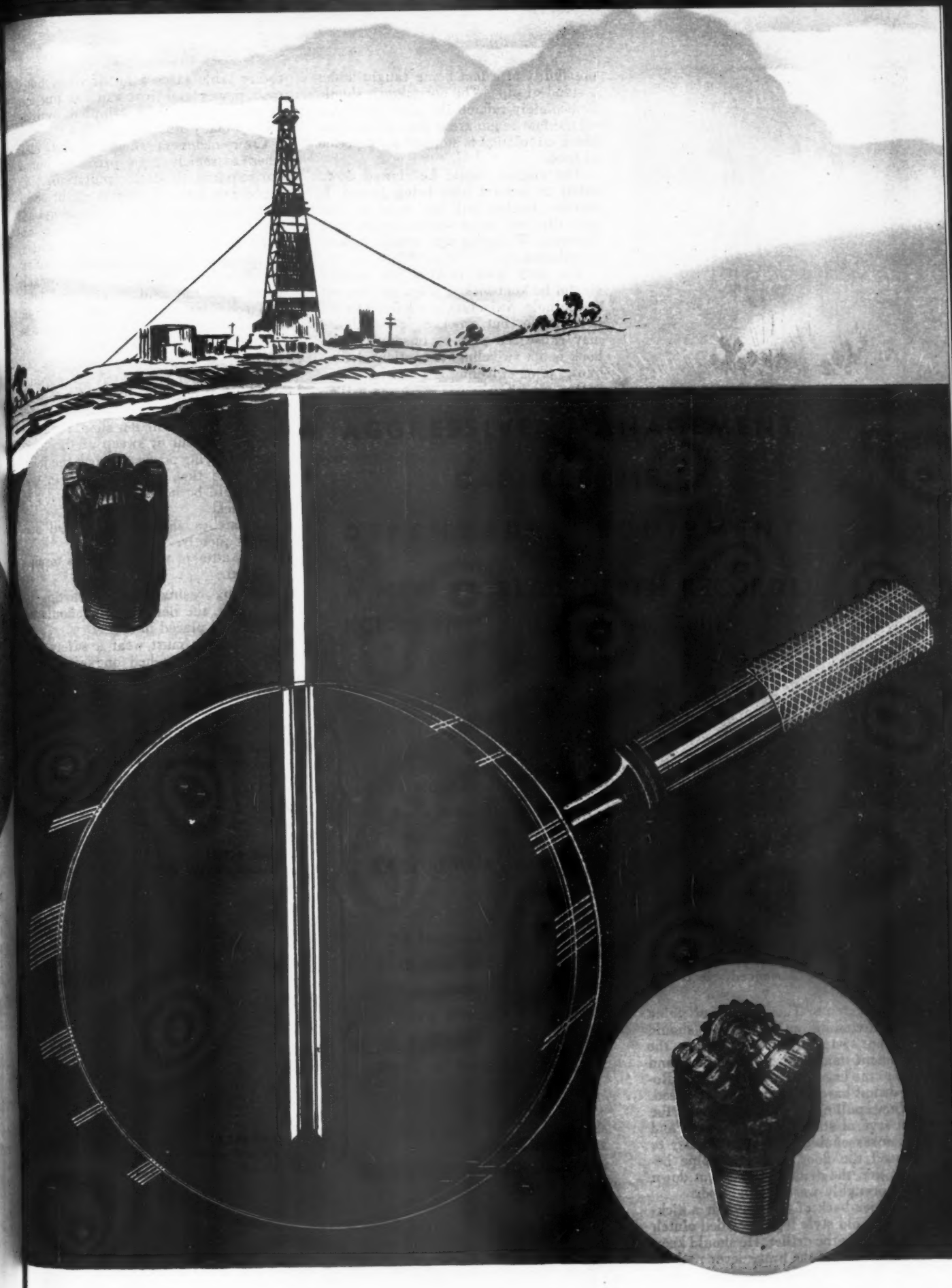

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● HOUSTON, TEXAS

A good example of a drilling rig equipped with life line and slide. Note fully enclosed ladder-way on back side.

(Continued from Page 137)

Extension cords to portable equipment should have a grounded neutral and all equipment should be vaporproof.

In case of breakdown, broken lines or shorts, an experienced electrician should be called.

▸ **Making trips.** The routine of going into and coming out of the hole should be done systematically. Speeding the equipment damages the machinery and adds to the hazard if a break occurs. Rotary drums have a definite limit of speed.

When pulling drill pipe out of the hole, several stands may be "wet" and it is unreasonable to ask the driller to wash off the floor, but when pipe becomes dry, the driller should shut down and thoroughly wash off the floor.

The kick-back of the brake or a kick-out of the old style leg-controlled clutch is a hazard to the driller. He should keep his body clear of the brake lever path.

The driller should keep close watch on the traveling block and elevators as they approach the derrickman. Wind or other deflections might foul the lines, blocks, elevators, and hooks. The driller and pipe racker should be alert to the possibility of a foot being caught under a stand of pipe. The derrickman should immediately relatch the pipe for lifting off the foot as gangrene may set in if the blood circulation is stopped for a period of time.

The engine should be slowed down safely to prevent pipe being jerked. If elevator latches fail, the stand of pipe may slip and cause serious injury to a floorman. Whipping pipe usually injures a workman.

The drill hook locking pin usually should be kept locked when coming out of the hole. Swiveling is a hazard to the derrickman, but crooked or bad holes may cause the pipe to unscrew if the hook is not swiveling. A cautious driller knows when swiveling is a hazard.

If a spinning line is used, the driller must see that it is in position on the pipe to prevent fouling. The end man on the spinning line must be instructed to release the line if it is fouled. Surplus coils of line on the floor are hazardous.

Slips should be held with the palm of the hand toward the drill pipe. Do not kick slips into place. When going in the hole, the pipe should be stopped by brakes before the helpers put slips in the rotary.

The kelly hook should be made secure in the swivel bail before it is lifted out of the rat hole. Repairs to the kelly joint should be made only while it is in the rat hole.

Greasing rotary gears while they are in motion is not good practice.

Drillers who "jump" or "dynamite" drill pipe are dangerous. Dropping one stand of drill pipe after another in the hole and catching it with the brake when the elevators are a few feet above the rotary table saves a lot of time, but it costs money and lives and has put men in their graves and crippled and deformed many others.

Crew members should stand clear when extremely high pressure pumps are required to start circulation. Hose rupture or gasket blowouts might occur.

In mixing caustic for mud, always add the caustic to the water. *Never add water to the caustic.* Chemical solutions for rotary mud usually burn flesh but are not injurious after being thoroughly mixed with the mud. Acetic and boric acid solutions or fresh water are antidotes for such burns. Goggles must be worn during chemical treating operations.

The floorman must latch the elevator only after it has been brought to a stop.

Break-out tongs must be snubbed with wire lines, but the driller should see that floormen are out of sweep of the tongs before applying power to break the joint. During the time tongs are not in use, they should be hooked in the corner of the derrick.

All latches should be cleaned and oiled frequently.

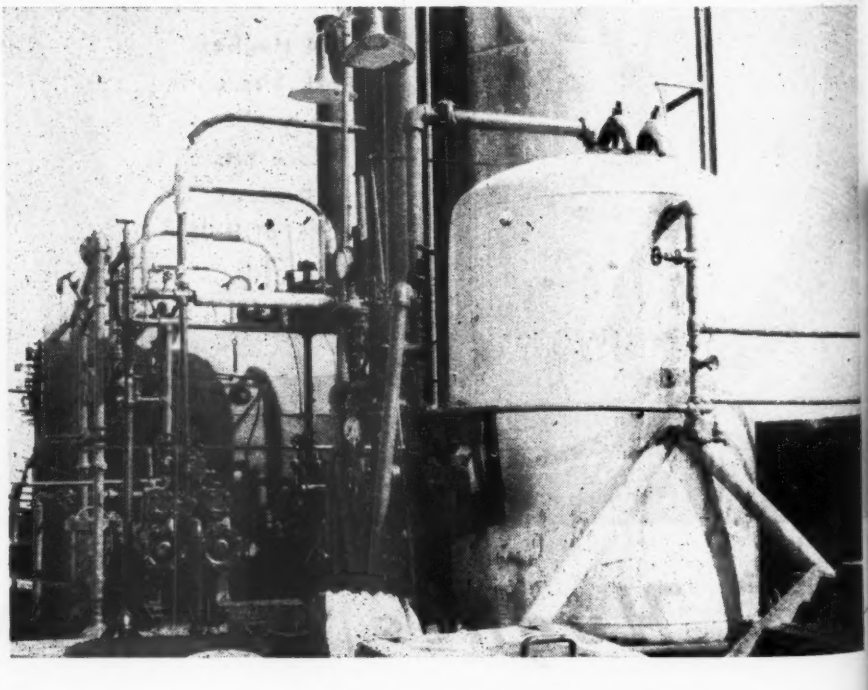
Never attempt to attach tongs to pipe in motion.

▸ **Running casing.** Before starting to run casing, the derrick floor should be cleaned and placed in order.

The stabber must wear a safety belt with life line attached one girt above the stabbing board, leaving slack enough to do his work. Some drillers string a soft line with a 4-in. ring across the derrick and attach the life line to this ring.

The stabbing board should be at least 12 in. wide, securely fastened at each end, and strong enough to hold considerable weight. The board is sometimes made of two boards with blocks parting the boards at the middle to form a truss.

Use only new rope if casing joint is picked up with rope and do not remove the rope tie or hitch until the pipe has



A well-equipped and safe boiler installation. Note proper walks and steps as well as ample lighting facilities. Piping, valves, pumps, and boilers have easy access.

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*Stoody Tube Borium is supplied in rods of ⅛", 5/32", ¼" and ⅜" diameters and is available for either oxyacetylene or D.C. electric application. Prices and specifications are yours for the asking.

These tungsten carbide particles do not melt when tube is applied but are held in suspension in a mild steel matrix forming a deposit resembling coarse sandpaper.

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Stop wear ... Eliminate Repair

been stabbed and turned several rounds by the floor crew.

Casing protectors must not be left on the derrick floor.

▸ **Cementing.** The high pressure required for circulation is a hazard during cementing. Workers should stay clear of the derrick floor or casinghead unless required for the operation. Lines should be firmly anchored to prevent whipping in case of a break.

Goggles and respirators should be worn by the men at the cutting table where cement sacks are handled or emptied.

▸ **Tools and tool house.** All tool houses should be kept clean and orderly. A first aid kit should be available and regularly inspected and kept filled.

Tools should be inspected regularly. Any tool in bad condition should be discarded or repaired. Chisels, punches, and cutter heads should be kept dressed down and all burrs removed. End wrenches with spread jaws are dangerous. Adjustable and pipe wrenches should have clean, sharp jaws and make a firm fit. In pulling wrenches, the force should be pulled toward the open end rather than away from the grip.

Hammers and sledges must have smooth, tight fitting handles.

Tools should not be carried by hand up or down a ladder. They should be raised or lowered in a suitable container.

Tools, machine parts, or material should not be kept in the derrick above the floor, except during use, at which time care must be taken to prevent their falling. When workers are using tools in the derrick, other members should stay clear of the derrick floor.

As soon as tools have served their purpose, they must be returned to their regular place. Do not leave tools and material scattered on walks and floors.

▸ **Protective equipment.** Goggles should be worn when:

1. Driving case-hardened drive chain pins.
2. Replacing pipe tong jaws, keys, or dies.
3. Cutting wire rope.
4. Pouring molten metal.
5. Handling cement, acids, or chemicals.
6. Breaking stone, cement, or cutting and chipping metal.
7. Working in or near welding operations.

Hard hats for head protection from falling or flying objects should be worn during all drilling operations.

Only shoes with leather soles and heels should be worn. Rubber is too slippery for wear around a drilling rig. Safety shoes with a steel toe box prevents many foot injuries and are recommended.

Clothing should be close fitting and free from saturation by oil and grease. Sleeves and pant legs should not be rolled up; if too long or ragged they should be cut off. Crew members should not be allowed to work without shirts. Only short snug-fitting gloves are recommended.

▸ **Smoking.** Open fires and smoking must be prohibited in or on the drilling rig. Matches and cigarettes should be left at the boiler or tool house where smoking can be permitted when at least 150 ft. from the well.

▸ **General.** Drilling operations are strictly business and require much hard work. They call for complete cooperation of every member of the crew. A moment's inattention or distraction may cause serious trouble. Therefore, horseplay and pranks are especially out of order and drinking intoxicants cannot be tolerated on the drilling job.

Good housekeeping around the rotary drilling job is good operation and it results in the elimination of lost tools and material, and reduces the fire hazard.

Each drilling rig has its own peculiar or unusual equipment and, therefore, these safe practices cannot cover all installations, but the basic theory of safety and good operations being inseparable should immediately suggest or create procedures to be followed in any type or phase of rotary drilling.

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★★★

Release figures on RFC expenditures for oil

Total subsidy payments on the production of crude oil from stripper wells from August 1, 1944, the date payments began, to December 31, 1944, were approximately $11,300,000, according to Jesse Jones. He added that all claims have not been paid by the RFC.

The government assisted in the payment of transportation costs of petroleum and its products from the midwest and southwestern sections to the eastern seaboard in amount of $279,400,000; the movement of crude from Texas and Louisiana to midwestern refineries was at a net cost of $4,000,000.

The RFC has disbursed $190,400,000 on loans and advances for construction of 100-octane aviation gasoline plants. In operating government-owned pipe lines, $438,200,000 had been expended at the end of 1944. Receipts totaled $505,700,000.

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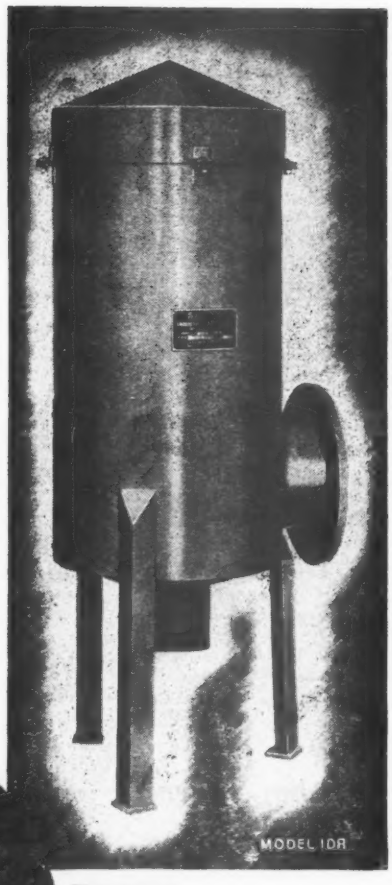

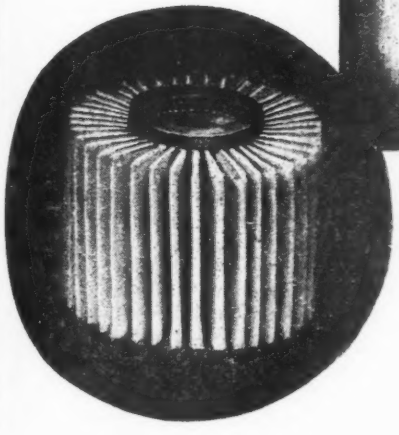

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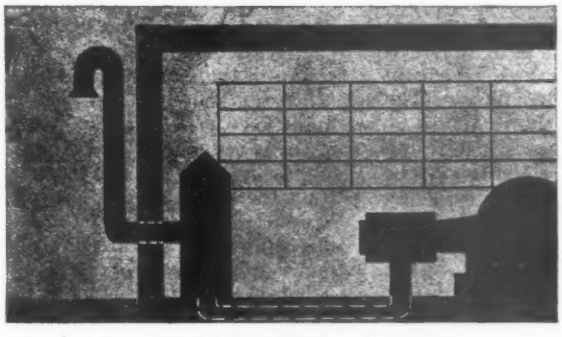
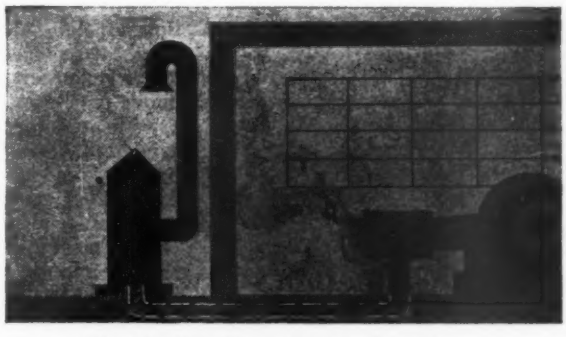
Models available with solid base for installation when compressor or engine intake is below floor level.



Model IDR INSIDE Engine Room



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HIGH TEMPERATURE STEAM FOR BUTADIENE

By **F. I. EPLEY**, Combustion Engineering Company, Inc.

EXCLUSIVE THE production of butadiene calls for a supply of high temperature steam in large quantities. Although the steam temperature is quite high and approaches the limiting temperature for commercial alloy materials, fortunately the pressure is very low. This combination of low pressure and high temperature permits the selection of materials that will resist oxidation at the high temperatures. It is not necessary, therefore, to give prime consideration to the creep of the material due to internal pressure. The problem of selecting proper materials is, therefore, simplified in that the oxidation and corrosive properties of the materials need only be given detail study and consideration.

The general conditions under which the high temperature steam superheaters discussed in this article were designed follow:

Steam throughput ..... 100,000 to 175,000 lb. per hr.
Steam temperature leaving ..... 1400°F.
Steam pressure leaving ..... 50 lb. per sq. in. max.

The steam enters the superheater as dry clean saturated steam and at a pressure sufficient to allow for the steam pressure drop in the superheater coils, which amounts to 100 to 125 lb. per sq. in. depending upon design and operating conditions for the individual installations. It can be seen from the above tabulation that steam temperature has considerable more influence upon the selection of materials than steam pressure. In actual practice the steam pressure leaving the superheater has been somewhat lower than the above mentioned pressure, which was used in the design of the equipment. In most instances the design pressure at the inlet section of the superheaters has been in the order of 200 to 225 lb. per sq. in.

In the usual type of superheater installation in which the superheater is installed integral with the boiler, the fuel-burning equipment is adjusted in relation to the steam output of the boiler so as to maintain a constant steam pressure at some point in the system. The superheater surface is situated at some point in the path of the furnace gases and the quantity of heat that it absorbs is a function of the gas temperature and gas weight at its location, and has no relation to the steam temperature desired except under one given set of conditions. The superheater surface, therefore, has to receive the heat that the gases wish to impart to it depending upon the various controlling conditions, and the steam temperature is uncontrolled unless there is some means of controlling the gas flow over the superheater or of controlling the heat input to the steam passing through the superheater by means of some kind of desuperheating device. It is a common practice to limit the steam temperature in such installations to about 1000°F., although the steam pressure may, in exceptional cases, range up to 2500 lb. per sq. in.

Three basic superheater types have been designed that may be used for the processing of butadiene.

Due to the extremely high steam temperature involved in superheaters for butadiene production, the most logical design would be to make use of separately fired superheaters. In such designs, the fuel burning equipment is adjusted to maintain a given required steam temperature. It is extremely difficult to design a large high-temperature superheater to be placed in a steam generating unit if the fuel-burning equipment is adjusted to maintain a given steam pressure that may be changed by the withdrawal of steam from the boiler section. It is essential, therefore, that for superheaters such as used in connection with the butadiene processes, a completely controlled or separately fired superheater be used.

Three basic designs. To date there have been three general designs of separately fired superheaters for high-temperature steam heating in connection with the butadiene processes:

1. One design consists of using independently fired units, and on these installations a large refractory furnace is provided in which the fuel is burned. The products of combustion are tempered with low temperature gases taken from the outlet of the superheater, thereby reducing the gas temperature to a level at which it can enter the tubes with safety, employing the principle of recirculation for the purpose of providing proper gas temperatures. If this system were not employed the gas temperature leaving the furnace would be near theoretical flame temperature and would approach some 3500°F., the only heat lost being through the furnace walls by means of radiation and convection to the surrounding air. This temperature is entirely too high for safe operation, and it is necessary to reduce it either by means of admitting an increasing amount of excess air or by means of recirculation of cooler gas. The admission of excess air is generally employed in small separately fired superheaters where the loss in efficiency would amount to a minor percentage of the value of the fuel. In the separately fired superheaters that have been built for the butadiene processes, the quantity of fuel required is considerable, and the amount that can be saved by utilizing the principle of recirculation will be sufficient to warrant the expense of the equipment required to accomplish the recirculation of the gases in order to maintain moderate gas temperatures entering the superheating surfaces. Heat-recovery equipment such as air heaters, economizers, etc., situated between the superheater and the stack, may be justified. Their use is purely one of economics in that the value of the heat recovered from the otherwise waste flue gases must be sufficiently high to justify the capital expenditure. Some credit, however, can be given to the use of air heaters in that the combustion of the fuel may be improved by the use of hot air.

2. A second design of separately fired superheater consists of installing a water-cooled furnace and a small amount of boiler bank surface in front of the superheater surface. The general pur-

F. I. EPLEY is a graduate of the University of Kentucky with a B.S. in mechanical engineering in 1927. He was employed in the industrial department of The Superheater Company from mid 1927 until the end of 1936, extending his efforts in the manufacture, design, research and operation of all type of superheaters for stationary and industrial use. Since the beginning of 1937 Epley has been employed at the same work for Combustion Engineering Company, Inc. The industrial department of The Superheater Company was merged with that company. During the last year he has been assistant manager of the Superheater and Economizer Division. Epley is a member of the American Society of Mechanical Engineers and is a professional engineer in New York.

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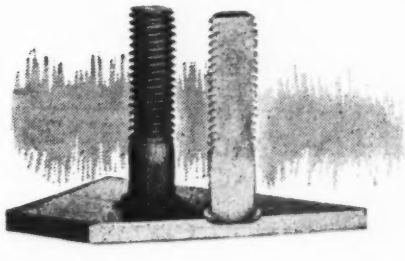

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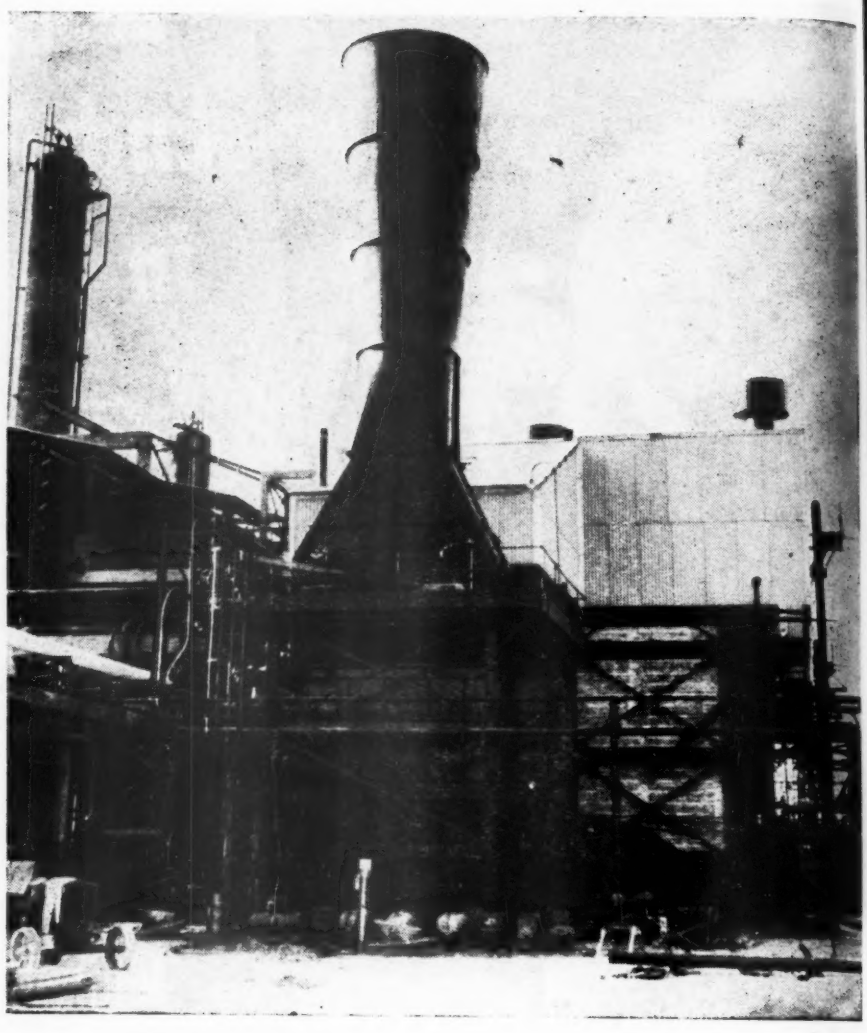
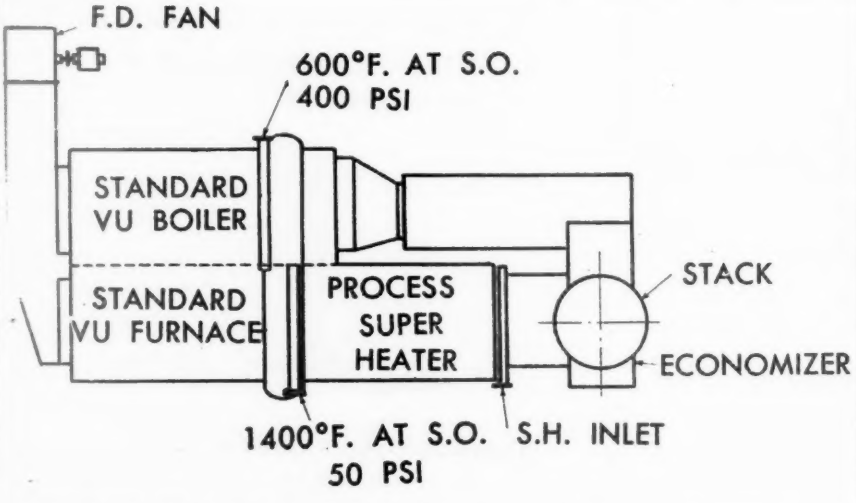
pose accomplished is the same as that accomplished with the refractory recirculation type of furnace. The furnace gases are tempered in this design by the absorption of heat in the water-cooled surfaces ahead of the superheater, and transmitted to the water in the tubes, thereby generating steam with part of the heat released in the furnace. By proper proportioning of the furnace and the water-cooled surface therein, it is possible to have the same quantity and same temperature of gases entering the superheater surface whether the furnace may be either of the water-cooled design or of the recirculating gas design. Each design has its advantages and disadvantages, and one or the other will be more suitable when the entire requirements of the process are considered. Heat-recovery equipment may be used to absorb some of the heat in the flue gases discharged from the superheater, and here again the value of the heat regained will determine the economics of installing such equipment.

3. A third design consists of an independently fired superheater such as the design discussed under paragraph 1 except that instead of tempering the furnace gases with recirculated cooler flue gas, for the purpose of reducing the gas temperature entering the superheater surface, radiant superheater surface is installed in the furnace. The heat that is removed from the furnace gases goes into the steam that is passed through the superheater coils. This is the same principle as used in many oil and gas heaters employed in various petroleum and chemical processes.



Rear view of Cities Service Company's Lake Charles superheater installation showing common stack with two units.



KEY PLAN—The unit is arranged with two separate, completely water-cooled furnaces having common upper and lower drums. Viewed from the front, the left half is essentially a standard 250,000-lb. per hr. Combustion Engineering VU type steam generator, which supplies steam to the power plant at 400 lb. per sq. in., 600°F. The right-hand furnace is similar but there are only five rows of boiler tubes. A multiple-element counterflow superheater, swept by gases from the right-hand furnaces and taking steam, up to 175,000 lb. per hr., from the 50-lb. station header superheats this steam to 1400°F. The gases from both furnaces pass through the economizer to a common stack. The total steam temperature is controlled by the amount of excess air admitted through the burners. The unit is fired by natural gas with refinery gas as auxiliary fuel.

▸ **Selection of materials.** One of the most important considerations in the design of high temperature superheaters, as well as in the design of any other high temperature heater used for heating liquids and gases, is the selection of materials. The research in the metallurgy of steel leading to the development of suitable and economical alloys for high temperature service has somewhat simplified the problems confronting the designer when compared with the problems that existed years ago. In the design of high-temperature steam superheaters, the problems encountered are not so difficult as those confronting the designer of high temperature heaters for petroleum products. Normally, the steam entering superheaters is clean and non-corrosive. If this is not true, relatively simple steps can be taken to insure clean steam being fed to the superheaters, and these steps must be taken in order to insure completely satisfactory operation.

Although the following materials may not be the only ones suitable for the design of high temperature steam superheaters, they have been found to be adequate and the service records of the vari-

A CROSS WITH A MESSAGE

★ *When the big crosses originally furnished on an important oil refinery job began to show signs of failure the contractors (one of the biggest and best firms of refinery engineers and contractors in America, by the way) decided to replace them with wrought and forged fabricated units.*

Like so many other difficult and exacting jobs this one was turned over to Taylor Forge, and the cross pictured above is one of a number made of seamless carbon moly tubing furnished by the contractor. The outlets are integrally formed to close tolerances. The run ends will be beveled like the outlets and Taylor Forge Flanges welded to both ends of the run and to the outlets. Perhaps in a later issue of this magazine we can show you the complete unit.

HANDLING jobs like this is a matter of knowing exactly how hot metal behaves and how to control its movements under pressure and impact. That knowledge, acquired through 40 odd years of experience and continuous research, is Taylor Forge's biggest single asset. It enables us to make WeldELLS and other Taylor Forge Welding Fittings exactly what they should be—to place the right amount of reinforcement just where it is needed, to provide tangents which keep the weld away from the most highly stressed zone. In short, to make WeldELLS the fittings that *"have everything"*.

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- **Precision quarter-marked ends**—simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
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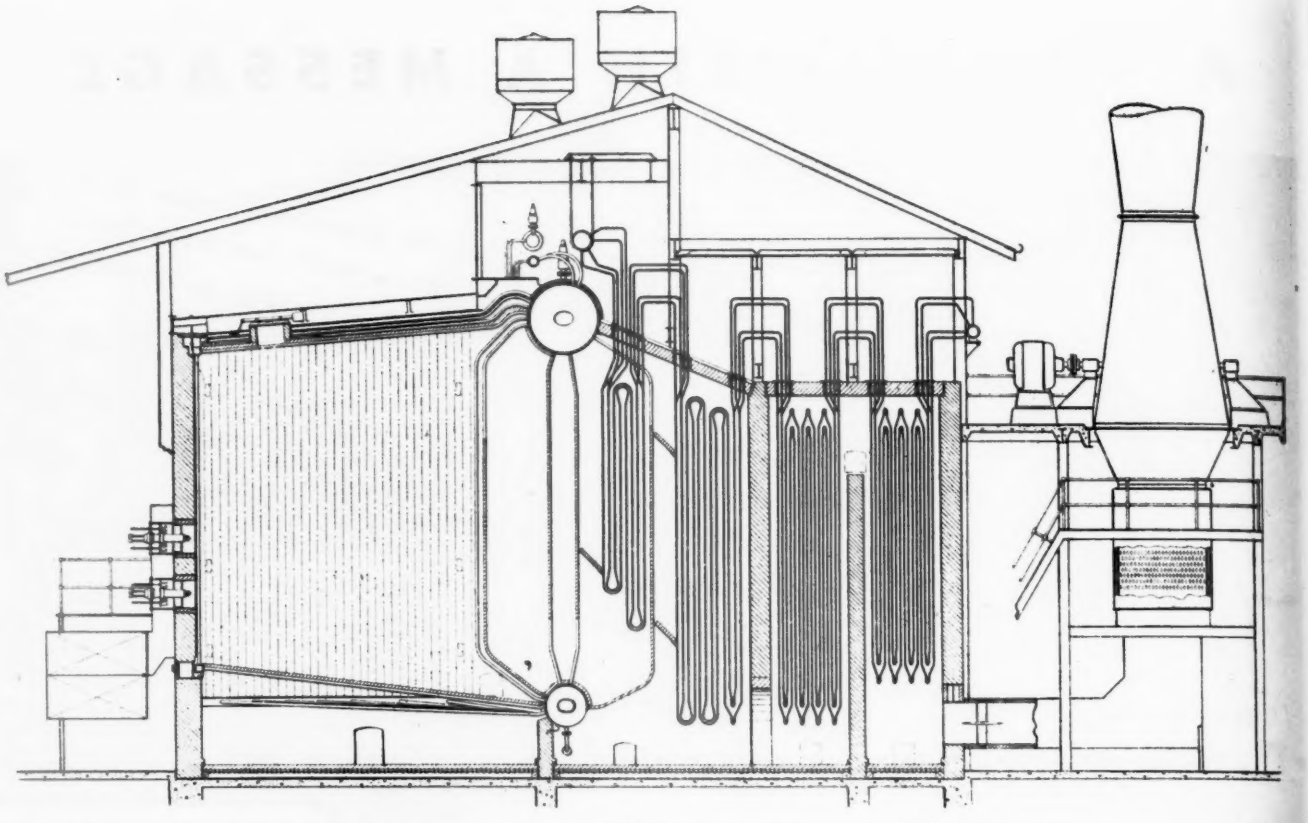

Sectional elevation of Lake Charles installation. See key plan for arrangement.

ous installations have justified the materials selected. The steam generally enters as clean dry saturated steam at 125 to 200 lb. per sq. in. gage pressure, depending upon the pressure drop through the superheater and the actual steam pressure required leaving the superheater. Low-carbon steel to various seamless or electric-resistance-welded tubing specifications have been found suitable for service temperatures up to about 900°F. metal temperature. The various analyses used for this section of the superheater may be in accordance with ASTM Specification A-83 Type A:

Carbon, per cent	0.08-0.18
Manganese, per cent	0.30-0.60
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.045 max.

ASTM Specification A-192 governs if the physical limits of the tubing come within the provisions of the following specifications:

Carbon, per cent	0.08-0.18
Manganese, per cent	0.30-0.60
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.045 max.
Silicon, per cent	0.25 max.

ASTM Specification A-178, Type A, governs in case electric resistance welded tubes are used:

Carbon, per cent	0.08-0.18
Manganese, per cent	0.30-0.60
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.045 max.

All three grades of steel tubing are satisfactory for the service temperatures encountered, 900°F. The tubing may be either cold-drawn or hot-finished, and no particular precautions are taken in making shop or field welds, other than those called for by the ASME Boiler Construction Code. The ASME Code does not require stress-relieving or heat-treatment of circumferential welds made in tubing of the size used in the construction of the high temperature steam superheaters. At the points where the carbon-steel terminals are welded to the saturated steam header, the ASME Code does require stress-relieving of the weld. This procedure is accomplished in the shop after the terminals are welded to the header and the entire assembly of header and saturated steam unit terminals are stress-relieved at one time. Occasionally, short pieces are welded together to form a single longer length of tubing, and this is generally accomplished in the shop by means of electric flash welding. No special heat treatments are required after carbon steel is flash welded.

Steam headers. The saturated steam headers are of medium carbon steel to ASTM Specification A-106, Grade B, the average analysis of which is shown in the following table. This material has been used for years for this type of service, and has been found to be quite adequate.

Carbon, per cent	0.35 max.
Manganese, per cent	0.35-1.00
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.06 max.
Silicon, per cent	0.10

The intermediate section of superheater surface may consist of chromium-silicon-molybdenum to ASTM Specification A-213 Symbol T-11, analysis of which is given in the following table:

Carbon, per cent	0.15
Manganese, per cent	0.30-0.60
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.04 max.
Silicon, per cent	0.50-1.00
Chromium, per cent	1.00-1.50
Molybdenum, per cent	0.40-0.55

The metal temperature expected to exist as the point of maximum temperature in this tubing is 1200°F. In joining commercial lengths of tubing together to provide the long lengths required in the superheaters, electrical flash welds are made in the shop. No special heat-treatment is required on these welds after completion. Field welds are also made in this material when the sections of the superheater are joined together after erection of the sections. The procedure of welding consists primarily in using a high chrome-nickel metal arc-welding rod. After making the field welds, the welded joints made in this alloy are subjected to the normal 1300° to 1400°F. heat-treatment. No trouble has been experienced with the welded joints made in this manner.

Other alloy materials such as ASTM Specification A-213 Symbol T-16,

Carbon, per cent	0.10 max.
Manganese, per cent	0.30-0.60
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.04 max.
Silicon, per cent	0.50 max.
Chromium, per cent	4.00-5.50
Molybdenum, per cent	0.40-0.55
Titanium, per cent	0.35-0.60

or other ferritic alloy steels listed under the ASTM Specifications A-213, would probably have given as satisfactory service in these sections of the high temperature steam superheaters.

The outlet section, which has to withstand the final steam temperature and is located in the hottest gas temperature zone, contains the best grade of alloy tubing because it is subjected to the most

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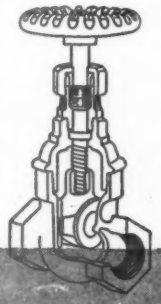

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severe service. High grade chrome-nickel alloy steel of the 18-8 analysis is required. The actual analysis of the alloy is that given for ASTM Specification A-213 Symbol T-18:

Carbon, per cent	0.10 max.
Manganese, per cent	2.50 max.
Phosphorous, per cent	0.04 max.
Sulphur, per cent	0.04 max.
Silicon, per cent	0.75 max.
Nickel, per cent	9.00 min.
Chromium, per cent	17.00 min.
Titanium, per cent	0.60 max.

The maximum metal temperature in the high temperature part of the superheater will be about 1500°F. Experience and the results of special research indicate that the above alloy will give satisfactory service at the metal temperatures that may be expected.

Shop welds, such as electric flash welds, made for the purpose of joining commercial lengths of tubing to form the required long lengths, have been performed in the same manner as those made in other tubing and have not been given any special heat-treatment. Field welds, used for joining the finished sections together and to the outlet headers, have been made with one of the metal-arc stainless-steel electrodes such as 19-9 (19 per cent chromium, 9 per cent nickel). It was thought by many that, inasmuch as the normal operating temperature of this type of welded joint was in the range of stress-relieving temperatures, it would serve no useful purpose to stress-relieve welded joints made in this type of alloy. Nevertheless, on some installations, these joints were stress-relieved before placing the superheater in service.

In all tube sections of the high temperature steam superheaters built for the butadiene processes, the main consideration has been to provide sufficient thickness in the tubing to allow for considerable scaling and losses in metal during operation. The fact that the pressure is low means that stresses caused by internal steam pressure are of little consequence. The situation is somewhat different in the outlet headers. Although the steam pressure is still quite low, the outlet headers are large, and the stress caused by the pressure is appreciable and of considerable importance. The outlet headers are fabricated of alloy steel plate, bent and welded together in the most approved manner. There are both longitudinal and circumferential welded joints, and the headers are thoroughly stress-relieved after shop fabrication is completed. The headers are made of alloy plate to ASTM Specification A-240 Grade T (Type 321):

Carbon, per cent	0.07 max.
Manganese, per cent	2.50 max.
Phosphorous, per cent	0.035 max.
Sulphur, per cent	0.03 max.
Silicon, per cent	0.75 max.
Chromium, per cent	17.00 min.
Nickel, per cent	9.00 min.

Steam superheaters have been built for steam temperatures as high and higher than the 1400°F. required by the butadiene processes, but they have in general been for rather small quantities of steam, being used either in pilot plants or in small production setups. The expansion of the steam capacity to the large quantities required during the present emergency is many times greater than the capacities for which high temperature superheaters have been built in the past. Many design problems had to be solved in building such large units and, judging from the results obtained to date with the present-day units, most of the operational troubles have been envisaged and features incorporated in the design to reduce these difficulties to a minimum. ★★★

Petroleum thiophene

A new process for making thiophene from petroleum has been discovered by Socony-Vacuum Oil Company, Inc. Thiophene, a colorless chemical liquid that alters the effects of medicines, the color of dyes, and some properties of plastics, such as brittleness, hardness, and elasticity, has been costing $54 a lb. The liquid is heavier than water and smells a little like benzene.

The new process will make this chemical cheaply enough to be manufactured commercially. Officials said it will be low enough for experiments in many fields of chemistry.

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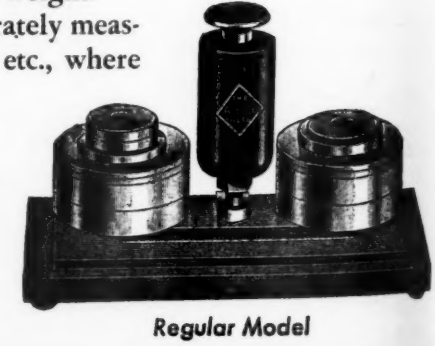

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DIESEL POWER FOR MEDIUM DEPTH DRILLING

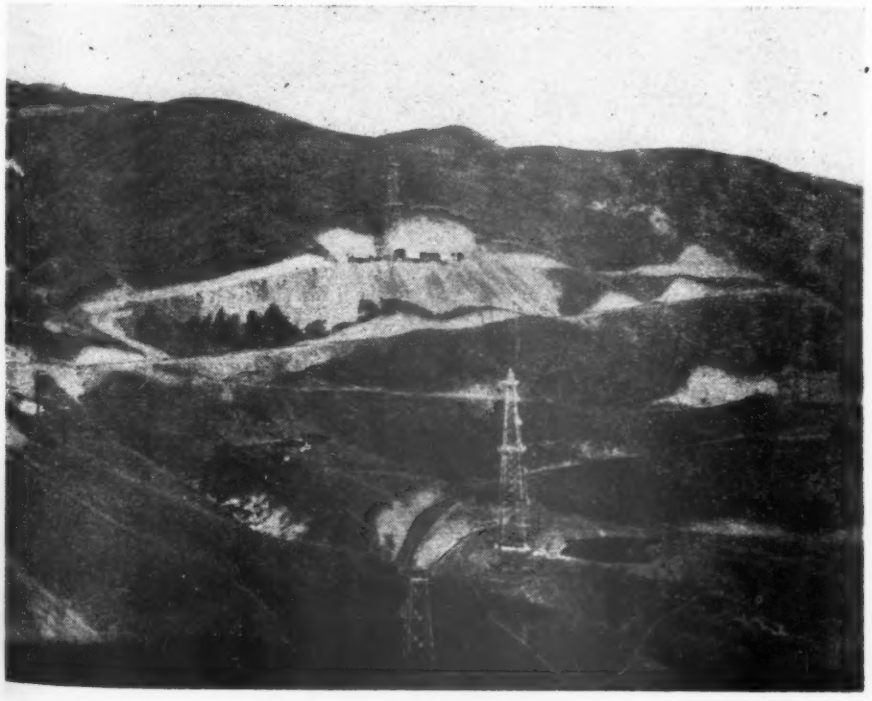
By **WALLACE A. SAWDON,** *Pacific Coast Editor*

EXCLUSIVE ALTHOUGH diesel power has proved its adaptability to rotary drilling operations, few full diesel engines have been employed in California fields. Steam has been used for depths up to and including the deepest well in the world, which was recently stopped in the Coles Levee field at 16,246 ft.; and gas, gasoline, and butane-fueled "sparkplug" engines have been employed to depths below 14,000 ft. Electric motor-driven rigs have also been used for a wide range of depths. In other states diesel engines have been applied more extensively and have supplied power for drilling from 13,029 ft. to 15,279 ft. in the Pecos County, Texas, well that held the world's record before the Coles Levee well was drilled to its total depth.

The great number of wells now being drilled to what at present is considered medium depths—say from 5000 to 9000 ft.—makes the type of equipment being used for this depth classification of considerable interest. The adaptability of diesel power to meet conditions under which it can be employed advantageously is indicated by a rig now drilling its second well in the Padre Canyon portion of the San Miguelito-Padre Canyon area. This area is very close to the shore of the Pacific Ocean northwest of Ventura, California, and west of the Ventura Avenue field, but it is mountainous in terrain. Well locations vary in elevation from a little over 200 ft. to more than 1000 ft. The roads are necessarily steep in many places and the size and weight of equipment is considered when transportation over these roads is necessary. Water is a problem in this area and some wells have been drilled with electric power in the Padre Canyon portion of the field. In the San Miguelito district, central steam plants have been used for groups of wells, the steam being piped to different locations as required. Supplying water for these operations, however, has been a problem.

The well now being drilled by diesel-powered equipment had 11¾-in. surface casing cemented at approximately 600 ft. and is being carried on with 10⅝-in. bits using 4½-in. drill pipe. It will be completed at a depth of approximately 8000 ft. where casing will be run to bottom, cemented and gun perforated.

The rig is of the consolidated type that is unified for transportation by truck from location to location. It consists of the two diesel engine drive units, a hoisting drum unit, and transportation unit, each mounted on a separate base. A main sub frame supports these units as a group and maintains proper alignment. The engines are placed in slight echelon, or staggered, with provision for compounding so that their combined power may be used for hoisting operations or for driving the rotary machine and one mud pump at desired speeds while rotating. Two pumps are used, one set below the derrick floor and driven through a V-belt by the rig engines and one powered by a separate diesel engine.



Looking across Padre Canyon. The topography of the area and roads necessary for transportation to wells are shown here. The diesel rig is drilling the well in upper center.

▸ **Diesel power.** The two rig engines are medium speed, 4-cycle, solid injection, 6-cylinder, full diesel engines with 8½-in. bore and 10½-in. stroke. They are equipped with radiator and fuel pump and have a rated 275 hp. at 900 r.p.m. The horsepower ratings are said to be conservative and to provide high overload capacity for emergencies and for quick starting when coming out of the hole with a heavy string of drill pipe. The engines are fully enclosed but the working parts are readily accessible.

Adaptability of diesel power to meet conditions under which it can best be used shown by California operation.

Fuel is injected into the combustion chamber through multiple holes in the tips of spray nozzles placed on a central axis in the tops of the cylinder heads, the sprays being discharged toward the periphery at a slightly downward angle. The nozzles are equipped with filters to supplement the main oil filter. Each spray valve is differentially spring-loaded and is opened only by hydraulic pressure. The quantity of fuel injected by the injection pumps is regulated to provide good fuel economy through a wide range of speeds and loads. All fuel pumps take fuel from a common supply line, which is under pressure maintained by a built-in rotary-type transfer pump. The lubricating system is of the full-pressure wet-sump type and is equipped with a main filter and bypass filter to provide continuous purification.

Control of engine speed is by means of a vertical centrifugal-type governor that is enclosed and gear-driven. This is linked to individual fuel pump racks to regulate the fuel admitted by a variable cut-off of the effective fuel pump plunger stroke.

The engines power the drawworks through a 1½-in. triple roller chain to the master clutchshaft. Compounding of the engines is by V-belt. The pump driven by the rig engine through a V-belt is

set below the derrick floor so the rear engine frame is notched to provide for belt clearance. This pump is a 7¾-in. by 15-in. pump with a rated capacity of 600 gal. per min. at 660 lb. per sq. in. when running at 60 r.p.m. Smaller liners are used to obtain higher pressures with smaller volumes, a 5½-in. liner delivering 320 gal. per min. at 1235 lb. per sq. in.

The individual diesel engine powering the second mud pump is of the same type with same bore and stroke as the two powering the rig except that it is an 8-cylinder engine with radiator and water pump, having a rated capacity of 375 hp. at 900 r.p.m. The pump is driven through a V-belt and is 7¾ in. by 16 in. in size.

Drawworks and transmission. The drawworks and the transmission are each mounted on separate skid bases but are bolted together to form a compact and integral unit. The drawworks drum is of 23½ in. diam., 35 in. length with capacity of 3175 ft. of 1¼-in. wire line. The drumshaft diameter is 7 9/16 in. The brakes are water-cooled and are 46 in. by 10 ⅜ in. in size.

A single control over all drawworks operations is provided by a master double-disk friction clutch with 30-in. diam. friction plates that engage the engine drive. The drawworks has 6 hoisting speeds and 3 rotary drive speeds. The three lower hoisting speeds are through a jaw clutch and the three higher ones through a friction clutch. The rotary machine speeds are through a friction clutch. With the choice of 3 rotary table speeds, one speed can be selected whereby both the table and the pump will operate in accordance with the driller's requirements. This not only permits distribution of the total engine power available to the rotary machine and pump as it is required for effective operation but also allows the compounded engines to share the load equally. Additional flexibility is provided by the use of 5 friction clutches of disk type.

The transmission employs a 2-in. pitch, double strand chain to provide 3 forward speeds, and constant mesh helical gears to provide reverse. Speed selection for the close coupled drives from the m ster clutchshaft to the jackshaft is made by jaw clutches. An inertia brake on the master clutchshaft outside the transmission housing facilitates the shifting of the transmission clutches and stops the catheads. The catshaft is driven by a 2-in. pitch single chain from the jackshaft by a sprocket mounted on the same hub as the drumshaft low-speed drive sprocket. An extended type cathead is mounted at the driller's end of the shaft. The rotary machine is driven through a countershaft mounted on the base in front of the drumshaft.

Drilling controls are placed at the driller's position, the master clutch, inertia brake, and engine throttles being operated from the handwheel. The throttle control permits either a coordinated control over the speed of both engines or a single control over either engine. A dual handwheel throttle control provides control of the speed of the engines from the extended cathead position. A single hand level provides for shifting the transmission clutches; foot pedals operate the drumshaft high and low speed clutches and the rotary drive clutch. A conventional hand lever is used for applying the drum brakes. ★★★

Two diesel engines are set in echelon to facilitate operations.

Push 100-octane output

To obtain maximum production of high octane aviation gasoline PAW has sent a special group to visit refiners and producers in order to help solve manpower problems. Under the direction of George Dewey, manpower counsellor of PAW, the group has already been in the Gulf Coast area. Three men have been assigned to that area in order that there will be no delay in handling manpower bottlenecks. They will maintain headquarters at the PAW offices in Houston, Texas. Dewey stated that the output of 100-octane gasoline had become so significant in the war effort that no slightest delay in production could be allowed.

Should I use water lubrication?

or what about oil lubrication?

Is this an open-impeller application?

or should I have closed impellers?

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FUELS OF THE FUTURE

By **B. H. WEIL,** Gulf Research and Development Company
Chief Information Specialist, Chemistry Division

ONCE upon a time, when man lived in caves, the fuel problem caused him relatively little concern. When his drafty domicile got too cold and his fur-lined dinner jacket began to feel inadequate, he would "cast another log on the fire," poke it a few times to make sure it caught, and then settle back to have his anterior toasted, although, unfortunately, he could hardly feel warm both fore and aft at the same time.

Today, however, the fuel situation is a bit more complex. Then, fuels meant heat alone; now, they mean motive power and light generation as well, not to mention their industrial applications. The cave man fought his wars with clubs, stones, spears, and crude bows and arrows; "civilized" man uses rocket bombs, incendiaries, and flamethrowers. Whether these latter refinements in the fine art of destruction constitute real progress is not quite clear, but it is certainly evident that progress has been made in keeping us warm, carrying us effortlessly on our way, and providing us with products unobtainable if modern fuel technology had not been developed.

Not that science is as yet able to perform miracles. Atomic energy remains untapped. The tides go unharnessed. The rays of the sun beat down during the day only to have the heat that they give the earth become dissipated during the night—barring that part, of course, that nature uses to grow crops and forests. The potential and kinetic energy in flowing and falling streams is tapped by numerous hydroelectric plants and, in some places, by water mills, yet by far the greater part is permitted to escape. More of these latter types of energy *could* be used if man became desperate, if present-day economics go by the boards; more *will* be used as science develops new techniques and a better understanding of principles.

Until all this comes about, however, the principle sources of the energy that man will use for generation of heat and mechanical work will continue to be those substances that nature used (many ages ago, usually) to store the plentiful solar energy of those tropical periods—coal, petroleum, and natural gas. Continued use will also be made of substances derived from these basic fuels, hence retaining at least part of their calorific value—manufactured gases, coke, and the like. Peat, wood, and other cellulosic materials should also be considered, although these are possibly of less importance than such at-present-little-used substances as tar sands and oil shale.

*Presented before Northwestern Pennsylvania Society of Engineers, Oil City, Pennsylvania, January 4, 1945.

Throughout history, man has used for fuel and energy those substances that were most abundant and inexpensive. This practice continues today, although the complexity of our civilization has caused some fuels to be given a higher monetary value per calorific unit than others because their physical nature has made them easier to apply. For example, the machine age has brought into being such mechanisms as the automobile, for which liquid fuels have proved most desirable, for their nature makes the feed problems relatively simple, thus keeping the weight and size of portable storage units to a minimum. Numerous foreign countries, lacking ready sources of petroleum, have used and are using combustible gases for automotive fuels but have neither been able to duplicate the performance of gasoline and diesel fuels nor do without heavy storage tanks (because gases must be highly compressed if any amounts are to be carried) or bulky generators if the gas is to be generated insitu from such solid fuels as coke, wood, corncobs, and the like.

Fuels have played an important role in development of American industry; a continued inexpensive supply is essential.

Similarly, the fuel gases are highly prized for home and industrial uses, where the ease with which they may be used when desired, without the need for at-the-site storage, gives them an edge over coal and oil.

Monetary and technical considerations, however, have a way of playing hob with fuel situations. Let natural gas increase in price; thereupon numerous house dwellers shift back to coal or oil. Let a state increase its tax on gasoline; purchasers of trucks and buses then give close attention to the practicability of using diesels. Let a revolutionary device such as jet propulsion become practical; airplane manufacturers at once consider its application to planes of all types, leaving the petroleum industry to wonder what types of aviation fuels will be required 10 years hence.

To cap the climax, so to speak, is the problem of supply. This may not affect us today other than as regards shortages directly attributable to the war, for we have become accustomed to thinking of our country as a "land of plenty," but it may very well alter our "world of tomorrow" before a great many years have passed. We have given little attention to this matter in the past, save for rare moments when the force of statistics struck a particularly hard blow, for Yankee ingenuity has each time given these statistics the lie for at least a few years.

As regards petroleum, for example, we are again in a period when statistics seem bespeak volumes concerning the future domestic picture. The discovery of new and unaccounted fields may again, as it has in the past, becloud the issue, but it would seem fairly evident that domestic supply will fall behind demand in the not too distant future. This statement is predicated upon the following logic: (1) Our "known" reserves approximate 20,000,000,000 bbl. of oil; (2) our 1941 production, which might be accepted as representative of what may be expected in the immediate postwar years, was 1,400,000,000 bbl., and (3) 20,000,000,000 bbl. divided by 1,400,000,000 bbl. per year, or roughly 14 years, does *not* represent the life of our present reserves.

Actually, if no more oil were discovered, and imports were impossible for some reason, we would not be able to continue even our peacetime rate of consumption for the evident reason that we could not continue to produce that much crude oil. Estimates of reserves are based upon oil recoverable by present-day methods, which strongly emphasize conservation and production over a long period; if these methods are disregarded and all-out production attempted, the figure of 20,000,000,000 bbl. would shrink considerably, nor could the remnant be produced in 14 years in any case. It is said, in fact, that our wartime demands for more and more crude *at once* have already caused the need for a downward revision in estimates. It is obvious, of course, that more oil will be found—probably much more oil. It is equally clear that we will import oil when and as we need it—oil has already been imported for some years from Latin American countries such as Venezuela and may even, at some future date, be imported from the Middle East, where estimated reserves dwarf those of ours.

THE bugaboo of a petroleum shortage, however, has several aspects. Granting, if you will, that domestic reserves will sooner or later prove inadequate, it would appear that world reverses will still be ample for a much longer time if consumption within the respective countries maintains anything like the present ratio. All would thus be well and we could again bury our heads in the sand were it not for the evident fact that the Atlantic Charter is *not* going to be strictly followed, that "power groups" are going to continue to make a hash of even reasonable and not starry-eyed attempts to apply the Four Freedoms. The international history of petroleum has a somewhat unpleasant smell; the future may not be so very different. Not

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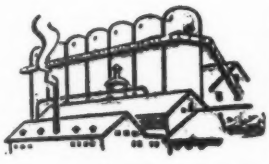

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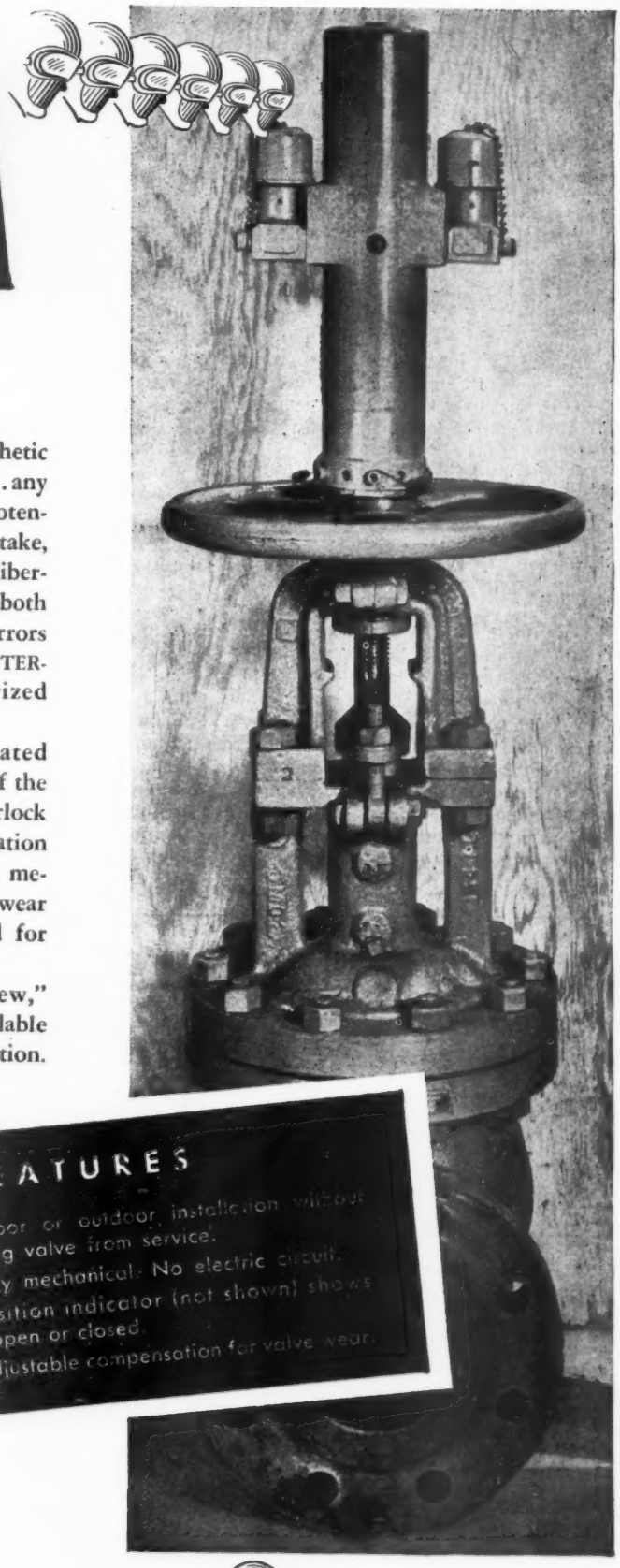

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that we are likely to lack oil (in peacetime) if and when we need it—enterprising domestic petroleum companies have acquired their share of foreign fields; the question is rather one of ham-stringing exchange agreements and other actions that do not exactly coincide with the best ideals of future inter-Allied harmony.

Another aspect concerns the possibility of another war or wars. We have already been taught one lesson in this war—by rubber. If we depend upon foreign petroleum to make up future domestic deficits, we may at some later date be faced with a problem that we cannot solve in time. The implications here are obvious; the solutions are not. One of them—the use of petroleum substitutes—will be discussed later.

In regard to coal, however, another picture presents itself. This is graphically illustrated by a recently-made comparison of oil and coal reserves that states that if present United States petroleum supplies were to be spread over the state of Ohio (41,000 sq. mi.) they would cover it to a depth of only ¾ in., whereas United States coal deposits would bury Ohio in a layer 76 ft. deep! It has been estimated that, if used at the 1941 rate of production, the United States' reserve of 3,178 billion tons of all types of coal would last for some 3000 years! Some grades of coal, such as anthracite and low-volatile bituminous, at the 1941 rate, would only suffice for a few hundred years, but the overall situation presents a startling contrast to oil.

Natural gas prospects are of an intermediate nature. Known domestic reserves are estimated at 110 trillion cubic feet—enough to supply the nation for nearly 30 years at the 1941 rate of production. The picture is further brightened by the fact that the ratio of natural gas to oil discovered has steadily increased in recent years, and it is believed that potential total reserves are on the order of 300 trillion cubic feet; or three times the amount of known reserves.

None of these "life" figures, of course, has any real meaning., for it is impossible to predict future demands other than to guess that they will continue to increase, thus reducing the life expectancy of the reserves. Future supplies of other fuels, such as coke and manufactured gas, depend upon the raw materials from which they are derived; because this is usually coal, no fear of shortage is felt.

Turning now to the subject of replacements for those natural resources that are in short supply, we find that the picture is confused—but only by economics. The word "only" should not be stressed, however, for economics are a dominant factor in our republican form of civilization. Were this country under totalitarian rule, we could (as regards technology) shift to synthetic gasoline, for example, in as little time as would be required to build the plants to make it from coal or natural gas—perhaps 5 or 6 years if construction material demands were not allowed to disrupt other industry requirements. The cost, however, would be appalling. At the 1941 rate of gasoline consumption, our annual gasoline bill—at the refinery, before taxes, and without profit to the manufacturer—would fall between $2,000,000,000 and $5,000,000,000, compared with about $1,500,000,000 in 1941 for the present-day petroleum industry. And the cost of the plants needed to produce this amount of gasoline — about 26,000,000,000 gal. per year—might be between about $5,000,000,000 and $13,000,000,000! Translating these figures into the cost of gasoline at the filling station, we would find ourselves paying the attendant between about 27 and 32 cents per gal. for the same grade of gasoline for which we now pay 22 cents.

These figures are largely based on extrapolated European technology and represent what we could do if had to replace petroleum *now;* American ingenuity is such that it is certain that costs can be lowered and that the public can expect gasolines of the present or slightly better quality—if that will suffice—to be available, for generations to come, at an average of not more than 5 cents per gallon above present prices.

The alarming part of the situation, however, is concerned with the danger of another war, which may come in the interim between the semidepletion of petroleum reserves and the time where prices are high enough to permit profit-

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able operation of substitute processes. This period may be lengthy, for vast quantities of foreign petroleum can be imported at prices competitive with or not for above present levels. And, as mentioned, a substitute petroleum industry cannot appear overnight, for the erection of plants would require perhaps 10,000,000 and 20,000,000 tons of steel—11 to 22 per cent of our annual wartime capacity—in the form of towers, drums, piping, forgings, compressors, pumps, reactors, and other items that require fabrication facilities as well as raw materials. It is for this reason that properly directed, fundamental government research, lacking the profit motive, can be of value in exploring phases of the subject that may later aid in hastening the day when substitute processes will become commercial. Such research, as we know, is envisioned in the 5-year, $30,000,000 research program now being conducted by the U. S. Bureau of Mines. Data obtained should prove a valuable addition to that already held and rapidly being acquired by the petroleum industry itself. Whether all this work will suffice as insurance against a petroleum shortage in another war, however, is another matter. No one answer to that problem is evident.

Any detailed discussion of or comparison between the known processes for the synthesis of petroleum is not timely here. In brief, they are:

(1) The hydrogenation of carbon monoxide, called the Synthine or Fischer-Tropsch process. This process, using natural gas, is almost competitive with crude petroleum, and several plants using it will probably be erected shortly after the war. As natural gas supplies are far from inexhaustible, however, it is certain that coal will eventually have to be used as the raw material. Even then this process appears attractive, for it may be possible eventually to bring the cost of gasoline produced by it down to as low as 9 cents per gal., which would be competitive with petroleum at $2.00 per bbl.

(2) The preparation of shale oil, either by pyrolysis of pyro-bituminous shale fragments or by hydrogenation. By use of the former method, considerable quantities of oil can be produced at costs comparable to or not much higher than present levels; the total oil content of known oil shale reserves may approximate 100,000,000,000 bbl.—a figure some five times as great as that for known petroleum reserves.

(3) The separation of oils or tars from sands such as are found in the Alberta province of Canada and in California and Colorado. Vast quantities of such sands are known, perhaps containing more than 250,000,000,000 bbl. of tarry oil, but it is questionable if more than a few billion barrels can be obtained at anything like present petroleum levels.

(4) The carbonization of coal. The small quantity of tars and oils obtained per ton are susceptible to cracking or hydrogenation for the preparation of gasoline, or, in some cases, can be used directly as fuel oils. Yields per ton by any known process are so low, however, that little use can be expected for them except where a ready market can be found for the major product, coke. A combination of coal carbonization with the Synthine process is possible, however, for coke is required for most of the present types of that method which stem from "coal."

(5) The hydrogenation of coal. As we have seen, coal is a most abundant substance, hence it constitutes the best raw material for use in any process for the long-term synthesis of petroleum-like oils. The hydrogenation of coal, however, is so complex and requires such expensive and elaborate equipment that it appears likely — unforseen developments aside—to be less attractive than the Synthine process using the same raw material.

Other substitutes and substitute processes exist but are more or less uneconomic on a comparable scale. As mentioned, producer or water gas generators may be attached to vehicles or stationary engines and the fuel gases used instead of vaporized liquid fuels. Other and compressed combustible gases—natural or synthetic—may also be used. A recent announcement claims the synthesis of "protoproducts"—oil-like materials—by controlled internal-combustion of carbohydrates under high pressures, followed by cracking or hydrogenation. "Power alcohol," the perennial toy of the various "farm blocs," will probably be advanced again and again, although costs by any known methods using any know materials are not competitive even with the hydrogenation of coal except for the production of relatively insignificant quantities.

In regard to fuel gases, the obvious substitutes for natural gas are the so-called manufactured gases—coke-oven gas, water gas, producer gas, and the like. These cannot at present compete with natural gas where the latter is cheaply available, but in 1939, for example, sales of the manufactured gas industry amounted to nearly 500,000,000,000 cu. ft., compared with natural gas sales of about 1,500,000,000,000 cu. ft.; both figures, of course, have since been exceeded, especially that for natural gas. Of particular future interest is some research being conducted on the synthesis of high B.t.u. gas by the Institute of Gas Technology, which is exploring the Synthine process as a means for either providing gas enrichment materials or the actual upgrading of low B.t.u. gases such as water gas into high B.t.u. "synthetic" natural gas. There would appear to be no danger of a shortage of gaseous fuels; higher prices, however, may cause abandonment of some of their uses.

Many of the subjects discussed so far relate to the comparatively far-distant future, even though they require present consideration. It may now be of interest to take a glance at what may be expected of the fuels of the immediate future, a period that will see crude petroleum derivatives still supreme among liquid fuels and natural gas still cheap and abundant.

All of us are now interested in a certain fuel whose wartime shortage has caused us considerable inconvenience—gasoline. Before the war, those of us who were not connected with the petroleum industry paid relatively little attention to matters concerning this substance. We were vaguely familiar with the term "antiknock" and the arbitrary system of "octane numbers" used to measure this property, but we took as gospel such sayings as "all gasolines are alike," used premium-grade fuels chiefly where the prices of both grades were rendered so high by taxation that the differential seemed negligible, and had no idea that "aviation gasoline" was anything but a somewhat improved variety of the gasoline we were using in our cars. Wartime experiences and the record of our air armadas has changed all this, however, and while "3-C" and "1-C" gasoline ratings are not common expressions, we are all familiar with the fact that our aviation grades of gasoline run way off the octane scale and that still better "superfuels" are required for B-29 and other recently-developed "dragons of the air."

Wartime aviation gasolines are typical of the highly-refined products that the petroleum industry is now able to produce. They are "gasolines" only in the sense that they contain selected hydrocarbons boiling within the gasoline range — "chemical gasolines" might be a better name for them. Certain premium gasoline fractions are blended into the present Grade 115-130 type, it is true, and form an important part thereof, but the major constituents are isooctane itself—synthesized from petroleum gases; isopentane—a hydrocarbon carefully fractionated from other hydrocarbons in refineries and natural gasoline plants or synthesized by isomerization from the far-less-desirable normal pentane; such "secret" and semi-secret blending agents as "cumene" and "C-S," which give "rich-mixture" performance—the ability to climb swiftly and take off with heavy loads; and Ethyl fluid — familiarly known as "lead" because of the tetraethyl lead it contains. The octane number of the final blend depends upon the relative proportions of the constituents used; the "superfuels" soon to be required will contain lesser amounts of the lower octane substances.

Much publicity has been given to the fact that the production of aviation gasoline now exceeds 500,000 bbl. per day. This is more than a tenfold increase over pre-Pearl Harbor levels and represents a gigantic accomplishment, nor is the task completed. What is unfortunate in this publicity, however, is the fact that numerous uninformed writers, noting that 500,000 bbls. per day is about 30 per cent of our 1941 gasoline consumption, have arrived at the conclusion that, since aviation gasoline has an average octane number of, say, 110,

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and since pre-Pearl Harbor gasolines averaged about 76-octane number, then postwar automotive gasolines ought to have octane numbers of over 90 or else that large quantities of 100-octane gasoline are going to be available for automotive use.

There are numerous technical fallacies involved in the first premise; among them, that the gasolines just won't mix quite that way. The economic fallacies of both conclusions are even more serious: Aviation gasoline blending agents cost at least more than twice the amount of an equivalent volume of straight gasoline, and many present plants can produce such agents only through highly uneconomic operations. The automobile industry comes in with a third objection; they state that they cannot, at least at present, design automobile engines that can derive any additional benefit from gasolines of higher octanes than 90 without running into mechanical difficulties that are as yet insurmountable; preignition of such fuels adds to the problem. The final touch is added by the fact that for 3 or 4 years after the war the great majority of cars will be of prewar origin, hence only a small number of these would benefit at all from gasolines above 82-85 octane number.

There is no doubt, of course, that postwar gasolines will exceed prewar gasolines in octane numbers. Numerous and large catalytic cracking plants, capable of turning out high-octane motor gasolines, have been built as part of the aviation gasoline program and will probably not be needed for that purpose in the postwar era. The fate of alkylation and isomerization plants is by no means certain, however, for their capacity will greatly exceed peacetime aviation needs and the costs of their products are far too high to use them in automotive gasolines, except in special instances.

It has been estimated—chiefly on an "expert opinion" basis—that postwar "regular" gasolines may not be higher than 78-octane in the immediate postwar era and that the octane rating of "premium" fuels will not exceed 82-85. It is highly likely that a few companies will surpass these levels for at least a brief period, but the value to the public will be questionable although advertising staffs will be highly elated.

There are basic chemical as well as mechanical problems involved in the use and production of high-octane gasolines. The type of hydrocarbons found in most straight-run gasolines and in many cracked gasolines do not have high octane numbers. Catalytic reforming processes increase the concentration of those hydrocarbons whose structure is more favorable, but some of these compounds, such as olefins and aromatics, have drawbacks, such as a tendency to preignite. "Branched-chain" hydrocarbons are also of high-octane quality, especially when the degree of branching is high, but it is not so easy to increase their concentration greatly. This is possible in the "chemical." aviation gasolines, but, as mentioned, the cost of such blending agents may prohibit widespread use in automotive fuels.

It would seem, therefore, that the petroleum industry will do well to produce gasolines of 85 to 90-octane number, which have satisfactory all-around qualities. If engine designers ignore the basic chemistry involved in fuel production and insist and succeed in passing these levels in the fuel requirements of their engines, the petroleum industry, as usual, will probably be able to meet the challenge, but with no assurance that costs will remain the same and with no guarantee that very large quantities of such fuels can be produced.

We have paid little attention, so far, to the type of automobiles that will be available after the war to use whatever fuels are produced. Much fantastic dreaming has been done on this subject, with the result that the public in general has been educated to expect something it is not going to get. E. C. De Smet in a recent speech before the Society of Automotive Engineers has characterized these "dream cars" as a "cross between an oversized beetle and a traveling showcase." Petroleum technologists are prone to be equally impatient with these rash predictions. J. B. Holland, for example, has described the designers' dream as an "automobile that looks like a peripatetic solarium—it is made of plastic, magnesium, or just spun air—preferably hot. In the lower price ranges the postwar cars will burn 100-octane gasoline, but the super de luxe models will require something much better—150-octane is mentioned as a possibility. Presumably exhaust gases, if there are any, will smell like Chanel No. 5."

Seriously speaking, the cars we are going to get immediately after production is resumed—sometime after VE-Day—will be 1942 models altered only to an extent comparable to normal year-to-year changes, and these changes will be chiefly ones in appearance—new, streamlined fenders, fancy grillwork, and different bumpers. New bearings developed in wartime may be applied, but present WPB restrictions rule out much possibility of major engineering developments, which normally come only every 3 to 5 years in any case.

G. H. Cummings has recently summarized the trends that may be expected in postwar Models No. 2, 3, and 4. These include: (1) Smaller engines, weighing eventually as little as 2 lb. per hp. as compared to the present average of 6 lb.; (2) less overall weight, somewhere between 2000 and 2500 lb. for cars of the type that now weigh 3000 lb.; (3) improved mileages, up to 30 miles per gal. when engines have been redesigned and cars made lighter; (4) numerous body styling changes, such as curved glass windshields and aerodynamic body designs; (5) rigid body construction; (6) automatic transmissions, expected to be standard equipment as soon as manufacturing costs can be brought down; (7) greater use of plastics, for example in the framework of front seats, but not for bodies in at least the predictable future; (8) longer wear, resulting from increased industry knowledge of metals and such processes as nitriding, and (9) sealed-in components, such as starters, generators, and (perhaps eventually) entire engines.

Cummings concurs in the belief that future engines will probably be built to use gasolines of 85-90 octane number, but he reports a wide variety of opinion on such changes as fuel injection, air conditioning, rear-engine design, and air-cooled engines.

The automobile industry is said to expect a number of 6,000,000 car-per-year years in the postwar era. It will be more than interesting to see if drastic engineering changes take place during that period.

Turning to the subject of airplanes, almost anyone can set himself up as a prophet with equal justification. All that seems apparent is that peacetime operations will be far below wartime levels, although civilian passenger and freight operations will continue to increase rapidly. There will not be a plane in every garage, however, nor will the immediate postwar air be full of helicopters. The complicated technical economics of the situation are extremely interesting but are far too detailed to discuss here. It must suffice to note that expert consensus has it that 100-octane aviation gasoline demand for the first 5 postwar years will probably not average more than 100,000 bbl. per day—less than 20 per cent of present output. What the situation will be like 10 years from now is anyone's guess. Jet propulsion or its brother, the gas turbine engine, may very well revolutionize fuel demands. Almost any combustible fuel can be used in these engines (with due regard to erosion and corrosion properties, of course), and, if the efficiencies of this type of propulsion can be improved, it would not be too surprising to find kerosines the aviation fuels of 1960. Then again, high octane gasoline internal-combustion engines may continue to be so improved that they may not be greatly displaced. Only the future can tell.

Naturally, gasolines are not going to be the only fuels of the immediate future. Diesel fuels bid fair to occupy an increasingly important place, both because of their innate economies—higher B.t.u. content per gallon, low cost (at least at present), and more efficient engine cycles—and the great strides in diesel engine development occasioned by wartime applications. So vast has been the installation of diesel engines in the navy's "small boats" that in October, 1943, navy diesels went ahead of steam in volume of horsepower produced. An estimated 25,000,000 hp. of diesel engines were produced in 1943, an amazing figure when it is considered that the cumulative horsepower of all the diesels ever manufactured in this country prior to 1942 totaled only some 19,930,000 hp.

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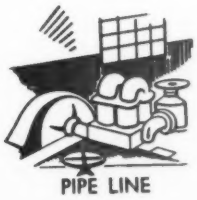
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Diesel-powered trains, trucks, buses, ships, and stationary engines were increasing in number prior to and during the war, and this trend will certainly continue thereafter. Even though much of the wartime horsepower installed is of an expendable nature, it would seem that postwar demands for diesel fuels would greatly exceed those of the past. Future quality levels for these fuels are not so clear, but it would appear that a retrograde trend in cetane numbers is not very likely. The supply picture is also clouded, for catalytic cracking plants prefer much the same distillate stocks for gasoline manufacture as are required for premium diesel fuels. How these problems are resolved should be interesting to observe—and important to industry.

Kerosine, incidentally, is still an important heating agent and illuminant. The future for it and the other "distillate" fuels is closely related to that for the diesel oils.

The heavy fuel oil problem is also quite complex. These fuels are the only petroleum products that are sold at a lower price than their volumetric share of the cost of crude oil. This net loss has occasioned much attention, and it is likely that an increasing quantity of postwar residual fuel oils will be converted into gasoline by various methods. Only a few users will be unable to shift to other fuels when and if this procedure causes an increase in prices and a diminution in supplies, for it is estimated that only about 25 per cent of the heavy fuel oil demand could not be met by coal. Postwar forecasts reflect the confusion among petroleum economists regarding the exact effects of these and other factors, some forecasters predicting a rise in demand whereas others prophesy a decrease.

The postwar use of natural gas is at present the subject of heated controversy, soon to be brought to a head at hearings conducted by the Federal Power Commission. Certain parties interested in strict conservation have joined forces with sectional interests who would like to reserve natural gas supplies for future use in the states in which they are found, and this combine, strongly aided by coal and manufactured gas interests (who do not care for competition with cheap natural gas), is fighting both nationally and in such states as Texas and Louisiana for restrictions on the interstate shipment of natural gas and for accompanying legislation to ban its use for certain purposes — such as boiler fuel. On the opposite side of the fence are the owners of huge fields that would be of little value for many years if such restrictions are imposed; companies operating gas pipe lines to regions (such as ours) in which natural gas supplies are depleted or nonexistent; companies planning new pipe lines, and the increasingly large number of household and industrial users who are naturally interested in paying as little as possible for their gaseous fuels.

It is far too early to predict the outcome of this argument. If prewar trends should be allowed to continue, the network of gas pipe lines will be expanded and will carry natural gas into "unexplored" regions. Unorthodox tankers carrying liquefied natural gas may ply the Northeastern Seaboard. In any case, it is likely that restrictive measures will be imposed that will rigidly prohibit the waste of natural gas even where this gas cannot be conveniently used, stored, or formations repressured. If these measures are as harsh as some would desire, they will constitute a "back-door" entry into government control of the petroleum industry, for natural gas is becoming an increasingly important and inseparable coproduct of that field.

Little need be said regarding the other fuels — coal, the manufactured gases, wood, etc. The uses of coal, for example, are certain to multiply as other fuels become scarce or more expensive. Supplies are semi-exhaustible, as mentioned. The trend toward increased use will probably be a gradual one, but it seems inevitable.

We have thus taken a fleeting glance at the "fuels of the future." This glance has revealed that the way is beset with so many interlocked problems and factors that no sharply-defined facts are evident, but it has also given us an indication of some of the issues that may be expected to play their parts. It would seem that the immediate postwar future, as regards the consumer, will not be so very different from the past. Our grand-

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children and their descendents, however, may find that their available fuels have wrought for them a civilization markedly different from ours. Whether the change will be retrograde—merely a struggle to replace diminishing supplies of natural fuels; or progressive—one in which superior fuels, abundantly and cheaply available, have aided in events, will depend upon our technical efforts and those of generations to come, aided and abetted — and not hamstrung — by government influence and attention. It is not safe to say that no fears for the future need be felt; it is better by far to take cognizance of the evident trends and to plan today to avoid trouble tomorrow.

Our fuels of the past have given American industry an edge over the less industrial nations of the world. If we are to maintain that edge, we must assure ourselves of a continued supply of inexpensive fuels. If we must ever again fight another war—Heaven forbid—we must see to it that no destructive shortages could develop. If we are again to enjoy the peacetime blessings of modern civilization and desire these for our descendents, we must plan wisely now as regards the "fuels of the future." ★★★

P 620.

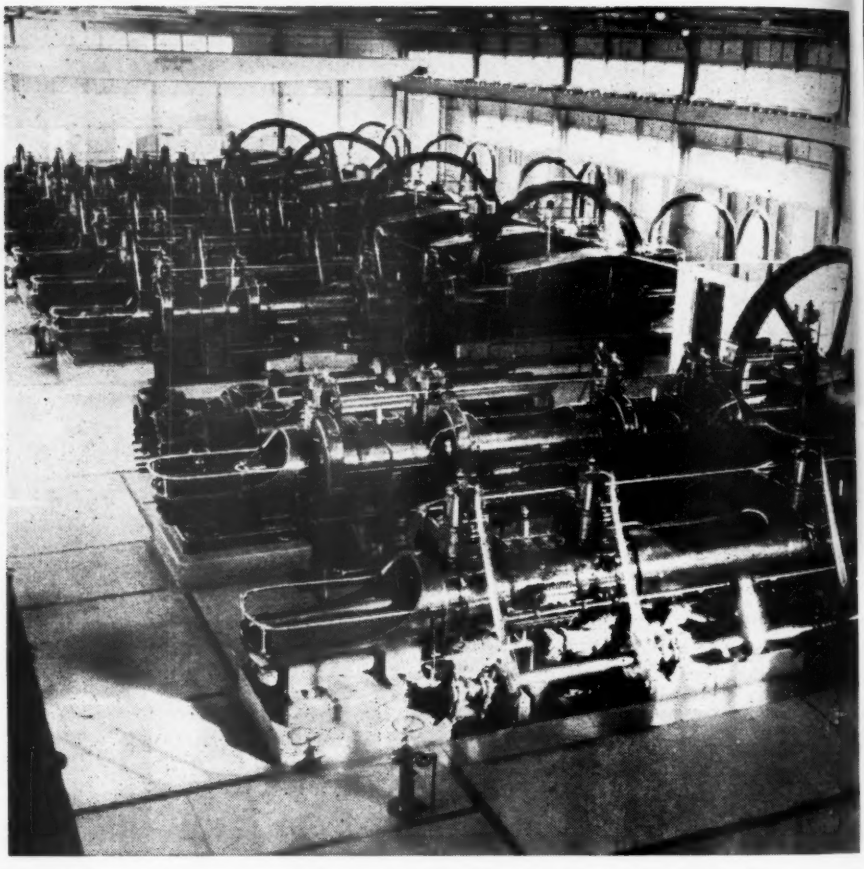
GAS COMPRESSORS IN SERVICE OVER 30 YEARS

SOUTHERN California Gas Company of Los Angeles, California, has four natural gas compressors, installed in 1913, that are still operating perfectly. These are Cooper-Bessemer units and three additional compressors manufactured by the same company have since been added enabling the company to increase output to 90,000,000 cu. ft. of gas a day.

The compressor station is at Taft, California, adjacent to the Midway gas and oil fields. Natural gas is piped from the gas fields to the north of Taft, compressed at the Taft station to a pressure of approximately 400 lb. per sq. in., and then driven through the long transmission lines to Los Angeles and other distribution points that serve the southern California area.

Station 40 has the distinction of being the first and one of the largest compressor stations in California. Of the seven compressors installed in the plant, four are twin units rated at 946 hp. each, and three are single units rated at 475 hp. each, thus making a total of 5209 rated hp. for the station.

Although certain parts replacements have been made on the four original compressors, the basic units are the same as installed more than 30 years ago. These compressors have a cylinder bore and stroke of 21½ in. by 42 in. and operate at 107 r.p.m. ★★★



Above—**Interior of Southern California Gas Company's natural gas compressor station at Taft, California. Four twin units and three single-unit Cooper-Bessemer compressors handle 90,000,000 cu. ft. of gas here daily.** *Below*—**These Southern California Gas Company officials are responsible for the efficient operation of the gas transmission system that serves a large portion of the state. They are, left to right, Elting Henderson, superintendent, gas distribution; William Moeller, vice president, natural gas division; and H. P. George, manager, natural gas production and transmission.**

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FOR ALL large-scale gas plant and pipeline design and construction, Parkhill-Wade offers a unique engineering service . . . a service not only for routine design and construction engineering, but also a service backed by our own latest developments in gas processing and gas handling operations. For example, here are important installations involving either Parkhill-Wade engineering . . . or construction . . . or both:

COMPRESSOR STATIONS Parkhill-Wade was consulting engineer to the Stearns-Roger Manufacturing Company in the design of the seven compressor stations—representing 58,000 horsepower—and the diethylene glycol dehydration plant for Tennessee Gas and Transmission Company's new 1265-mile gas pipeline. . .

COMBINATION PLANTS Parkhill-Wade has engineered six combination dehydration and desulfurization units for natural gas purification. These units, using a mixed solution of monoethanolamine and diethylene glycol, perform in one operation the removal of CO_2 and H_2S, together with partial dehydration. Final dehydration units, either of the solid adsorbent or straight glycol type, complete the dewatering operation. . .

STRAIGHT DEHYDRATION Construction of a straight diethylene glycol dehydration plant is now being completed for a large California utility. This plant will operate at 1000 pounds per square inch pressure, and will handle 150,000,000 cubic feet of gas per day. Another recent completion in California will dehydrate 50,000,000 cubic feet of gas per day at 400 pounds pressure—and both plants represent the most outstanding developments available today in gas dewatering!

Whatever may be your problem in gas processing, Parkhill-Wade engineering ability and extensive experience can help you. Investigate the many important developments . . . our engineering staff will be glad to answer your requests for more detailed information.

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Parkhill-Wade engineers and designs systems of all kinds for processing natural gas and the lighter hydrocarbons. We will be glad to make recommendations—or work with you toward solution of special engineering problems. Write, outlining your requirements.

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SALT WATER DISPOSAL IN EAST TEXAS

EXCLUSIVE ONE of the most important properties of a reservoir rock is its porosity. In a quantitative sense porosity is the per cent of the total bulk volume that is made up of pore space. Porosities of sands are known to range from zero to 40 per cent. Values in excess of 30 per cent are uncommon and most oil reservoir sands range from 10 to 25 per cent porosity. The average of a large number of tests on samples from the productive portion of the Woodbine sand in the East Texas field was 25 per cent. Tests were confined to "effective" sand and ranged from 17 to 31 per cent generally. Sandy shales and shaley sands were not considered as effective reservoir rock and the amount of such material, along with shale and ash, is subtracted from the sand thickness, or accounted for by a "sand factor." In general the East Texas reservoir becomes more shaley toward the south where the sand factor changes from 80 per cent in the Gladewater area to about 65 per cent south of Turnertown. That is to say, 80 per cent of the reservoir is composed of shale, sandy shale, or other non-productive material in the north whereas the amount of these materials increases southward.

Shale partings in the sand are very irregular in occurrence and in thickness. Few of the shale layers can be correlated from well to well even with the aid of electrical logs. The consensus is that these shale layers are of small areal extent and in most cases will have but little influence upon the movement of fluids in the reservoir.

Porosity. The porosity of a reservoir is a measure of the pore space in the rock but it is not the only factor necessary to determine the amount of oil that can be held in it. This results from the fact that oil reservoirs also contain water known as connate or interstitial water. This water is believed to have saturated the sand at the time of deposition and its salinity depends upon the conditions of sedimentation.

In the East Texas field an average of 17 per cent of the pore space is occupied by connate water. In general the higher connate water percentages are found in the sand zones with the smallest grains or smallest intersticial passages, and less water is found in coarse sands and gravels.

The volume of oil contained in an acre-foot of sand is calculated in the following manner:

$7758 \times P \times (1\text{-}C) \times (1\text{-}S) =$ bbl. of oil in one acre-foot, net sand.

Where:

7758 = volume of 1 acre-foot expressed in bbl.,
P = porosity,
C = connate water, and
S = shrinkage factor (21 per cent for East Texas).

CHAPTER 1. SECTION D
Characteristics of the WOODBINE RESERVOIR

The volume of oil contained in 1 acre-foot of average East Texas field sand is:
$7758 \times 0.25 \times 0.83 \times 0.79 = 1270$ bbl.

The amount of this oil that will be recovered depends upon how the reservoir is produced.

Although it does not directly affect the volume of oil that can be held in a reservoir, permeability is very important when it comes to getting the oil out of the reservoir. The permeability of a reservoir rock is a measure of the resistance offered by it to the movement of fluids through its pore spaces. The standard unit of permeability is called a darcy. A porous substance is said to have a permeability of 1 darcy, if a fluid of 1 centipoise viscosity will flow through a cross-section of 1 sq. cm. at the rate of 1 mm. per sec. under a pressure gradient of 1 atmosphere per cm.

Permeability. The permeabilities of oil reservoirs are usually expressed in millidarcys, and values range from 10 to 15,000 in producing fields. The permeability of the East Texas field averages about 2000 millidarcys. The flow of fluids in reservoirs is complicated by the fact that oil, gas, and salt water are often present at the same time, and the permeability of the rock to any one of these fluids depends upon the relative amounts of the other fluids present.

The viscosity of East Texas crude oil is 0.93 centipoise at the reservoir temperature (145°F.) and containing all of its original dissolved gas. If the gas is liberated, the viscosity of this oil at reservoir temperature is 1.86 centipoise. This has a direct bearing upon recoveries under different types of reservoir control.

The rate at which a single fluid will flow into a bore hole may be calculated by the following equation:

This is the fifth in a series of lectures on the subject. The first part was published in the September issue and others were carried consecutively until January when there was no installment. Another part will be run in an early issue. The whole series will comprise an important and complete course in this phase of production.

$$PI = (5.9 \times 10^{-4}) \frac{KH}{UFV}$$

Where:

PI = productivity index bbl. per day per lb. drop,
K = permeability in millidarcys,
H = sand thickness, ft.,
U = viscosity, centipoise, and
FV = formation volume factor, (1.26 for East Texas crude).

This is an empirical relation developed by Lewis of Core Laboratories, Inc. Similar formulae may be used to compute water injection rates.

The permeability of a rock is closely related to its pore spaces. The larger the pore spaces, the higher the permeability. If the degree to which gas and oil replaced original water from pore spaces is limited by the size of the pore spaces, it follows that the connate water content must bear some relationship to permeability.

In order to test this relationship, connate water and permeability tests were run on the same samples. It was found that connate water content increased when permeability was decreased. In the case of East Texas, permeabilities of 600 to 6000 millidarcys had a connate water content of 6 to 15 per cent, whereas samples of 15 millidarcys had a connate water content of 30 per cent. A sample of 4 millidarcys had a connate water content of 46 per cent.

The average connate water content for East Texas Woodbine sand is 17 per cent. This is relatively low, due to the relatively high permeability encountered in the field.

The relationship between connate water and permeability does not exist between fields, however. In some Gulf Coast fields, such as Tomball, the connate water content for a given permeability may be 2½ times that of East Texas. In such fields the connate water may average 45 to 50 per cent. Obviously, this leaves considerably less space to be filled with oil or gas.

The quantity of oil or gas contained in reservoir porosity is reduced by the quantity of connate water present.

Permeability of a formation to the flow of oil is greatly reduced at water saturations above 15 per cent and more energy is required to move a given quantity of oil through the formation. If this energy is limited, lower recoveries of actual oil in place will result. Thus not only will there be less oil in the formation because of high quantities of connate water, but also less oil will be recovered.

A fairly definite oil-water saturation ratio exists for a given sand or field, which determines whether or not that formation will produce clean oil, oil and water, or only water. If an oil sand is highly saturated with connate water to begin with, only a small quantity of oil

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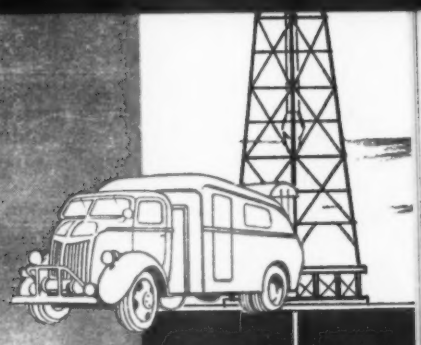

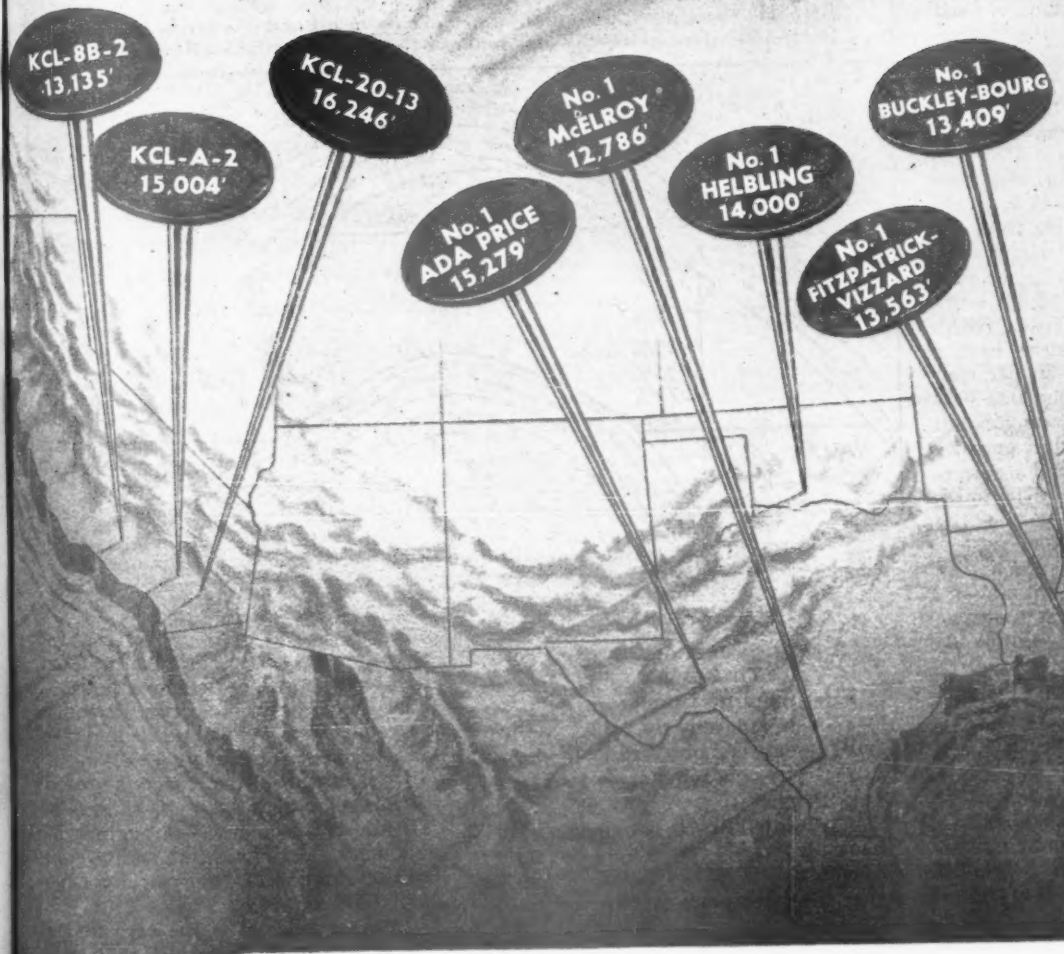

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would have to be removed before water would be produced from the entire formation. This would require early artificial lift and the production of large quantities of salt water before the oil reserve would be entirely depleted.

To measure permeability in the laboratory, the volume of dry air passing through a clean dried sample cut to specifications is measured. The permeability can be calculated from the dimensions of the sample, the pressure differential, and the viscosity of the air.

Although porosity does not decrease with grain size (assuming uniformity of grain size), permeability does decrease with a decrease in the size of the grains. This should be apparent from a comparison with fluid flow through pipes. Small openings offer more resistance to flow than larger ones. Sands are usually made up of grains of angular shape and assorted sizes. (Generally 0.004 to 0.016 in. in diam.) In general, a large percentage of coarse grains gives a higher permeability than a large percentage of small grains. A wide distribution of grain size will make for low permeability. Shale lenses, silt in sand, and cementing material all tend to lower permeability.

Typical porosity and permeability values are listed in Table 2.

In general, Appalachian reservoirs have an average porosity of 12 to 15 per cent and permeability ranging from 5 to 50 millidarcys. In the Oklahoma area, porosities range from 15 to 25 per cent and permeabilities from 25 to 400 millidarcys. The sands in East Texas, North Louisiana, and South Arkansas have a porosity range from 20 to 30 per cent and a permeability range from 50 to 3000 millidarcys. The Gult Coast and South Texas areas have sands with a porosity range of 25 to 32 per cent and a permeability range of from 100 to 2000 millidarcys.

In the foregoing discussion, permeability has been spoken of as the ability of a porous medium to transmit a homogeneous fluid, whether air, water, gas, or oil with gas completely in solution or with no dissolved gas.

The equation used in figuring the permeability is as follows:

$$K = \frac{uQL}{A\,(P_1 - P_2)}$$

Where:

K = permeability in darcys,
u = viscosity in centipoise,
Q = volume of fluid passing through the specimen per unit of time,
L = length of specimen, cm.,
A = cross-sectional area of specimen in sq. cm.,
P_1 = input pressure at the core face in atmospheres, and
P_2 = delivery pressure at the downstream core face in atmospheres.

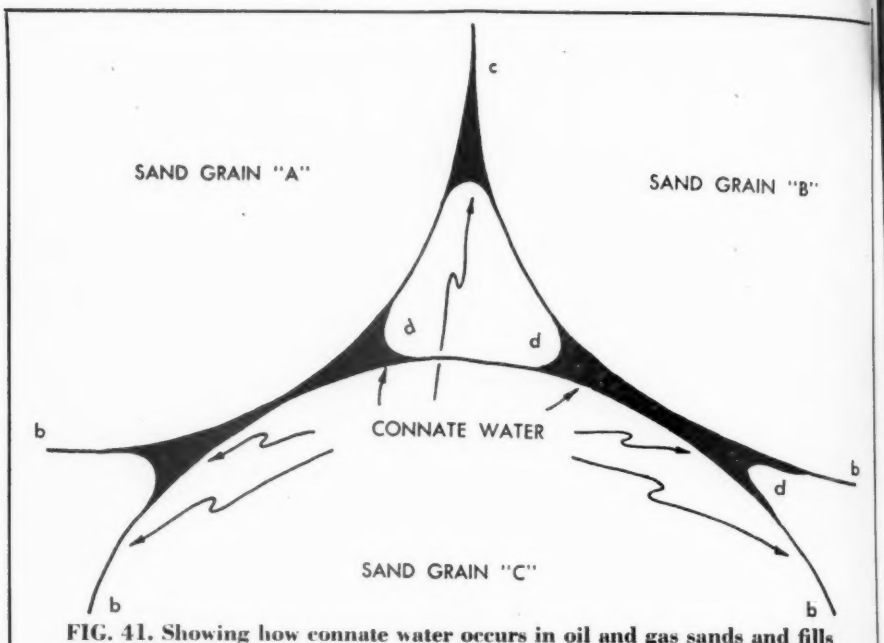

FIG. 41. Showing how connate water occurs in oil and gas sands and fills the smaller pore spaces "d" and makes a thin film over the sand grains "b".

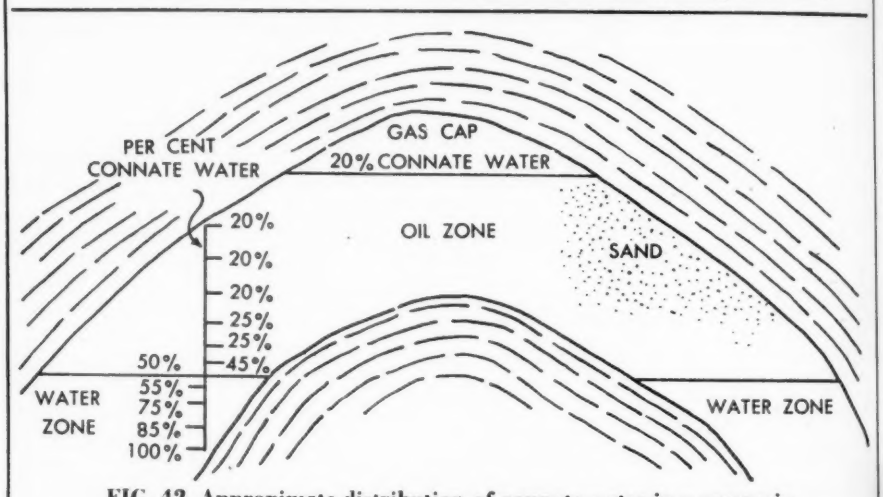

FIG. 42. Approximate distribution of connate water in a reservoir.

A gas-oil mixture is not homogeneous, that is, it is not a single fluid but rather a combination of two fluids. When the oil in the reservoir is saturated with gas at the prevailing pressure, there is likely to be free gas moving through the formation to the well bore along with the oil. East Texas is a noteworthy exception; here the oil is undersaturated with the gas. In other words, more gas would dissolve in the oil at the reservoir pressure if the gas were present to be disolved. Therefore, the oil moves through the formation as a dead fluid with no free gas as long as the flowing reservoir pressure is above 740 lb. per sq. in.

In most fields it is the expansion of the originally dissolved gas that moves oil through the formation, but that expansion must be controlled by avoiding excessive pressure drops, for as the percentage of the gas in an oil-gas mixture increases, the permeability of the sand to the mixture decreases. This is shown graphically in Fig. 43.

It is seen that the permeability of a sand to oil is reduced by half when the mixture contains about 18 per cent free gas. When it contains 50 per cent free gas, the permeability is reduced to about 10 per cent of its original value. Likewise, the permeability of a sand to gas

TABLE 2
Typical porosity and permeability values

Sand	State	Field	Porosity per cent	Permeability, millidarcys
Bradford	Pa.	Bradford	12.5	2.60
Bradford	Pa.	Bradford	14.3	4.53
Wilcox	Okla.	Seminole	15.9	350.00
Woodbine	Texas	East Texas	22.1	3390.00
Woodbine	Texas	East Texas	26.9	2500.00
Woodbine	Texas	East Texas	19.7	192.00
Woodbine	Texas	East Texas	27.7	1020.00
Wilcox	Okla.	Okla. City	16.9	677.00
Wilcox	Okla.	Bowlegs	12.8	88.00
Tokio	La.	Pine Island	18.4	.....
Henderson	Texas	Rodessa	16.8	65.00
Floyd (lime)	Texas	Rodessa (Jef.)	20.0	130.00

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is reduced by half when the gas contains 35 per cent liquid.

These are laboratory results and may not exactly duplicate reservoir conditions, but they indicate generally what happens when a gas-oil mixture flows through a porous formation. Thus it would seem important to keep gas in solution as long as possible in order to obtain the greatest ultimate recovery of oil.

This may be compared to foamy beer and clear beer. The clear beer will strain through a filter much more readily than will the suds.

Oil-water mixtures have a similar behavior to gas-oil mixtures as regards a mutual lowering of permeability to the fluids. The relationship is best expressed by Fig. 44. This graph shows how the permeability of a core to either oil or water is reduced when in presence of each other under reservoir conditions.

Thus for a particular saturated sand body, oil moves through more freely than water up to about 50 per cent water saturation. Above 50 per cent water saturation, water moves more freely than oil. This accounts in part for the rapid increase in water production, which often occurs in the life of a water producing oil well. It indicates that if possible and economical, water production should be shut off by plugging back. When the water production of a well increases, it becomes harder and harder for oil to flow to the well bore, and progressively easier for more water to do so.

FIG. 43.

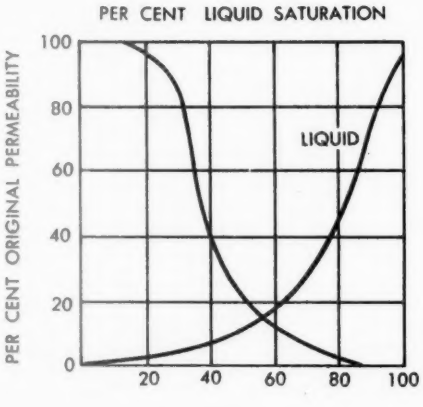
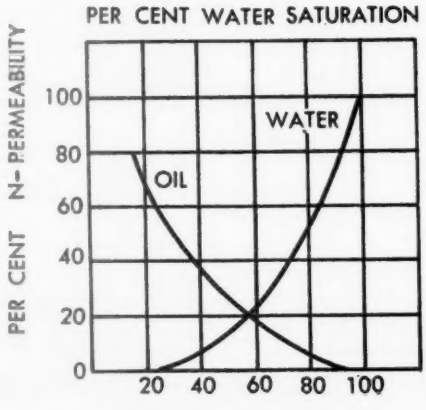


FIG. 44.



CHAPTER 2
History and Development of SALT WATER DISPOSAL
Section A. Surface Disposal

THE disposal of the salt water produced with crude petroleum and natural gas has long been a constant source of trouble to oil and gas operators as well as to farmers and stock raisers in the vicinity of producing fields. The amount of salt water produced from wells on new properties may be almost negligible, but some older wells may produce several hundred barrels a day.

Often the production of salt water can be decreased materially and the production of petroleum increased by the use of bottom-hole plugs and by a general repair and cementing of wells. In many fields subsurface conditions such as encroaching edge water obviate effective remedial measures to reduce the water production. Also, in wells where the water enters from the lower part of the producing sand there is a definite margin of depth to which the water can be plugged off without reducing the oil production. With these conditions existing it is evident that the disposal of salt water is an ever-increasing problem.

▸ **Natural evaporation.** The evaporation pond is by far the most commonly used means of handling salt water mainly because of the comparatively low initial and operating costs. The pits ordinarily have an area of 500 to 10,000 sq. ft. and a depth ranging from 1 to 15 ft. Apparently no effort has been made in the East Texas field to determine the quantity of salt water that a pond of given size is capable of handling by natural evaporation and seepage, as ponds of every size and shape imaginable and constructed of soil scraped from the immediate area, are to be found throughout the field in every depression and slope that would allow for storage, no thought being given to wind barriers and other conditions that affect evaporation.

A fact early established was that it would not be possible to dispose of much water by evaporation in the East Texas area, because annual precipitation and evaporation are almost equal. Evaporation pits, winding ditches that weave back and forth across a hillside with the reservoir at the bottom, are methods that now fall short of disposal requirements in the field. The annual rainfall in this area is about 42 in. whereas the evaporation is about 52 in. Evaporation is heaviest during the season of small stream volume.

The quantity of water vapor in the surrounding atmosphere is indicated by the relative humidity. The removal of water vapor from above the evaporating surface by air movements is directly controlled by wind velocities. The several atmospheric factors affecting the rate of evaporation are interlocked, and it is impossible to select any one particular factor as the major influence. It must be kept in mind, however, that the area of the evaporating surface is a factor of importance, and that other conditions being the same, the greatest proportion of water will be evaporated from those ponds having the greatest evaporating surface per barrel of brine.

▸ **Seepage from ponds.** It has been stated by Scofield that in clay formations the rate of penetration or percolation of a water is greatly influenced by the colloidal condition that the clay has assumed, which in turn is brought about more or less by the chemical composition of the infiltrating water. Any ions present in the water, such as sodium or potassium, which tend to deflocculate the clay, will render the clay relatively impervious to the infiltration of water. On the other hand, such ions as calcium and magnesium, which flocculate the soil, will conversely cause the clay to become relatively permeable to the infiltration of water.

The percolation of salt water through clay, where the water contains ions some of which act as flocculating agents and others as deflocculating agents to clay, depends on which of these two agents predominate.

From observations on evaporation ponds the following conculsions can be made:

The evaporation pond should be free from surface drainage.

The evaporative surface should be increased to the maximum possible, and the depth should be held at a minimum consistent with the required storage facilities.

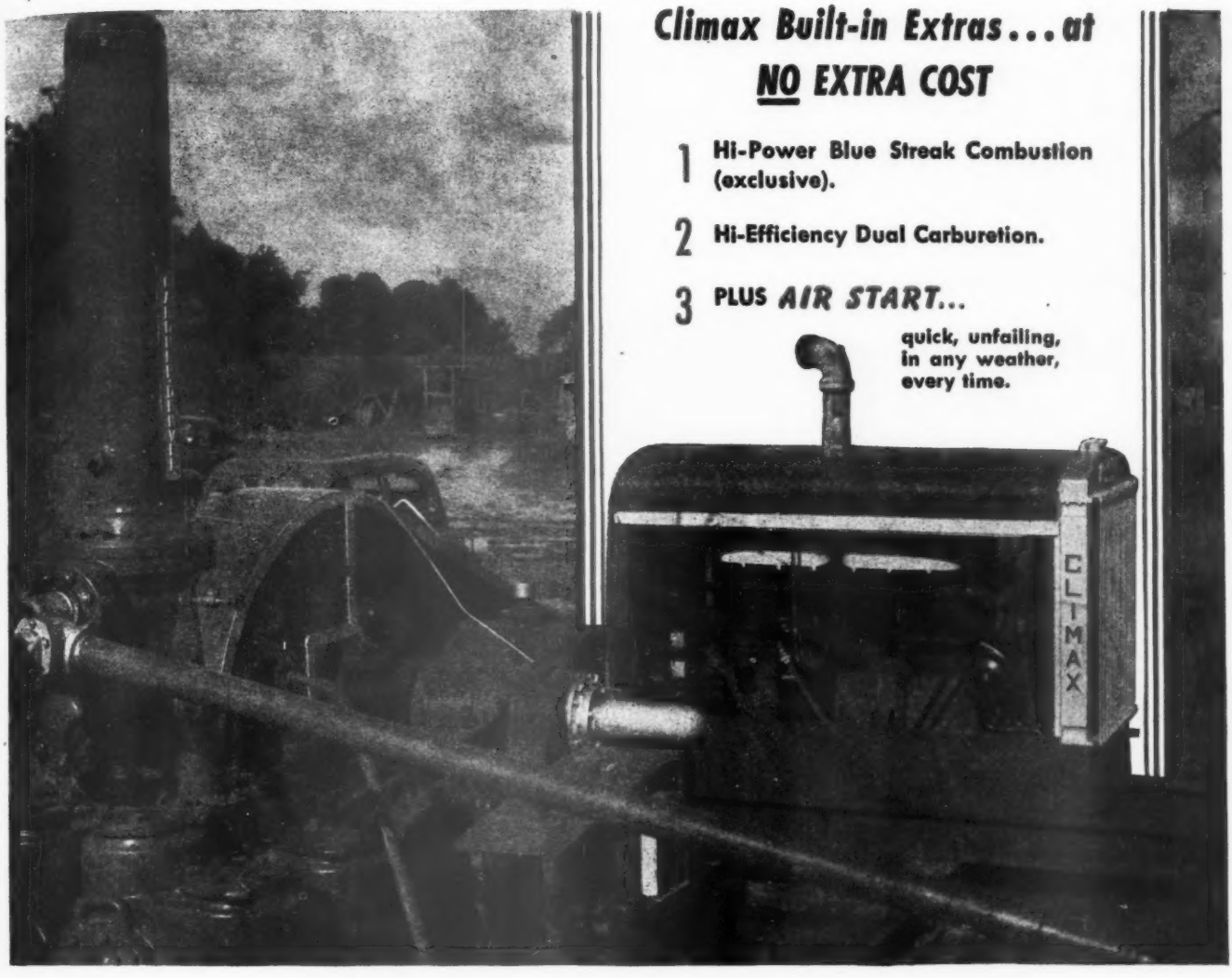
Wind should have free access from all sides.

B. S. and oil should not be allowed to accumulate on the surface of the pond.

▸ **Release to fresh water streams.** When the field produced 20,000 to 30,000 bbl. of salt water daily, disposal was a routine matter. Release of stored water to flooded streams during rainy periods afforded an outlet during the early history of the field. With salt water production now equaling about 40-60 per cent of oil production, disposal during the dry periods is adding sharply to production costs on dozens of large leases.

The state law permits a maximum of 2000 parts of salt to 1,000,000 parts in streams that run or drain regularly into larger streams. This maximum permits the release of about 1 bbl. of salt water for every 25 bbl. of fresh water carried by the stream, since salt water from the Woodbine sand carries from 36,000 to 40,000 parts of salt per million parts by weight. Ordinary sea water contains from 26,000 to 29,000 parts of salt per million parts.

The Sabine River, principal stream near the East Texas field, and its tributaries, are capable of handling a large volume of Woodbine water yields, if it could be released evenly and properly. The Angelina and Neches rivers are major outlets for the south end of the field. Due to the dry season and uneven flow during other times of the year, disposal by this method holds limited promise.



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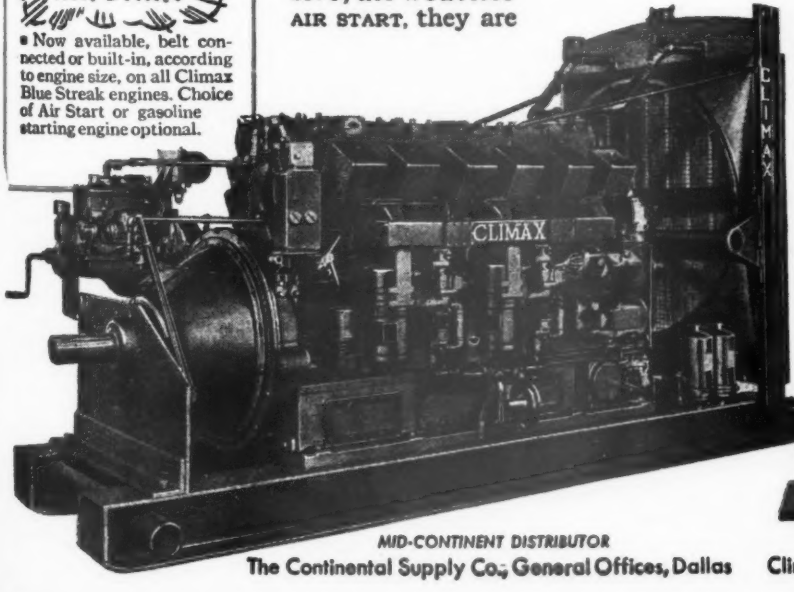

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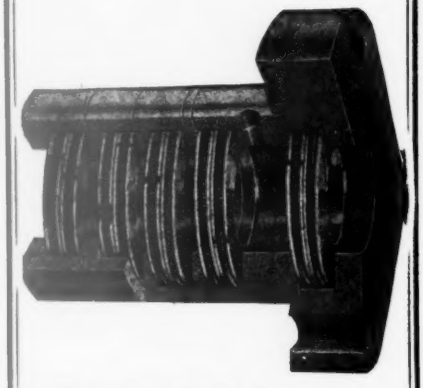

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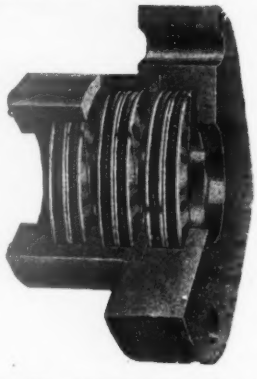

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Artificial evaporation. Few efforts at artificial evaporation as a means of disposing of salt water have been made and records of such efforts are not available. One project that involved the burning of natural gas in a vat of water in an effort to obtain finely-divided carbon, resulted in the development of a simple means of disposal of salt water by artificial means. The water was evaporated very rapidly and efficiently by this means, leaving a black vitreous mass in the bottom of the vat. There is no market for this product, and the problem of disposal of the waste would become great in time.

A variation of the process described above was tried. This comprised the use of a vertical flue in which were suspended strips of wool blanket. The upper portions of these strips were continuously immersed in shallow troughs of brine. In the base of this flue was placed one of the special gas burners used in the above experiment. Evaporation of the brine occurred very rapidly because of the large surfaces thus exposed to direct contact with the hot combustion gases. Incrustations of salts formed on the lower portions of these blanket strips and were extremely difficult to remove. Fibreglass was substituted for the wool blankets, which allowed for easy removal of the incrustations.

The incrustations thus recovered comprised crude sodium chloride and no serious difficulties were encountered in purifying this crude salt. Any attempt at commercial operation of this method of disposing of salt water would result in having to dispose of large volumes of crude salt to prevent accumulation.

Section B.
Subsurface Disposal

Experimental injection into the Woodbine sand—Jarvis well.

Early in 1931 the East Texas Anti-Pollution Committee prepared a report on the following methods of salt water disposal:

1. *Discharge into natural drainage.*
2. *Storage and controlled discharge into natural drainage.*
3. *Injection into Woodbine sand.*
4. *Solar evaporation.*
5. *Mechanical evaporation.*
6. *Canal to Gulf.*
7. *Pipeline to Gulf.*

In order to determine the feasibility of the third method mentioned above, a number of operators in the East Texas field pooled their resources and drilled an experimental disposal well approximately 3 miles west of production and it was known as Jarvis No. 2. In order to have sufficient water for injection tests it was necessary to construct earthen storage pits of sufficient size to impound approximately 350,000 bbl. of water. It was decided to use the temporarily abandoned Sun Oil Company's Jarvis No. 1 well located approximately one mile east of the disposal well as a source of Woodbine water. The well was reconditioned and pumping equipment installed. The production averaged 3500 bbl. per day. As the water was being impounded it was pumped over an aerator and thoroughly aerated. Due to the fact that it required several months to produce sufficient water to fill the pits, the settling time was very great compared to that which would be possible under ordinary operating conditions in the field. After sedimentation, the water was pumped through pressure sand filters and introduced into the disposal well.

The disposal well was drilled to 4013 ft.; 10 in. surface casing was set and cemented after which 170 joints of Duroline casing was run to 3832 ft. and cemented with 150 sacks. The I.D. of the Duroline casing was 5¾ in. The well was underreamed to 8 in. with cable tools.

Work on the project began about October, 1935. Production of salt water from Jarvis No. 1 was started January 4, 1936, and the full capacity of the earthen storage pits was accumulated by July 1936. Some preliminary testing was done in July and August 1936, but the final and conclusive test was started on September 10 and ended on December 16, 1936. During that sixty-one day period approximately 381,550 bbl. of water were injected into the disposal well. Various rates of input were established under varying operating conditions but it was determined finally that the well was capable of taking at least 10,000 bbl. per day by gravity, and that sufficient evidence was at hand to indicate that the injection rate could be increased to 20,000 bbl. per day without requiring excessive pressure at the casinghead.

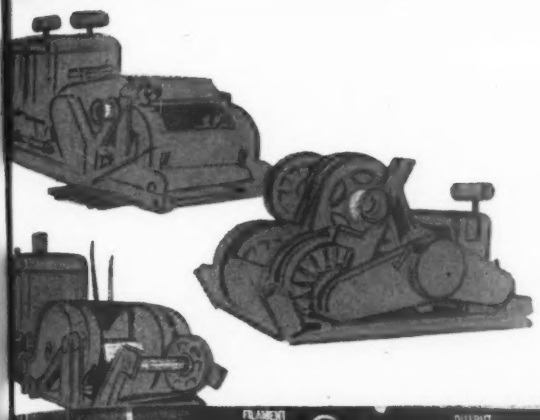
The capacity of the filters used in the experiment was 10,500 bbl. per day. The ability of the well to take 20,000 bbl. per day by gravity was calculated on the basis of fluid levels in the casing under various input rates.

It is interesting to note that during the time the water was in storage in the earthen pits it was necessary to circulate it over the aerator and to treat it with chemicals in order to put it in satisfactory condition for injection. Alum was used to control the floc in the pits and copper sulphate treatments were necessary to control the micro-organisms that began to grow in the pits. ★★★

Polish production up

The oil fields of eastern Poland were yielding 60 per cent as much oil by October, 1944, as they produced in the prewar period, according to reports from the foreign press. At the same time 25 refineries and 2 plants for the extraction of natural gasoline from natural gas were back in operation. Electric power plants and facilities for testing and experimenting also were in operation.

Before the war 65 per cent of Poland's petroleum production was from the fields in the eastern part of the country. Computed on this basis, the present production is 200,000 metric tons annually.



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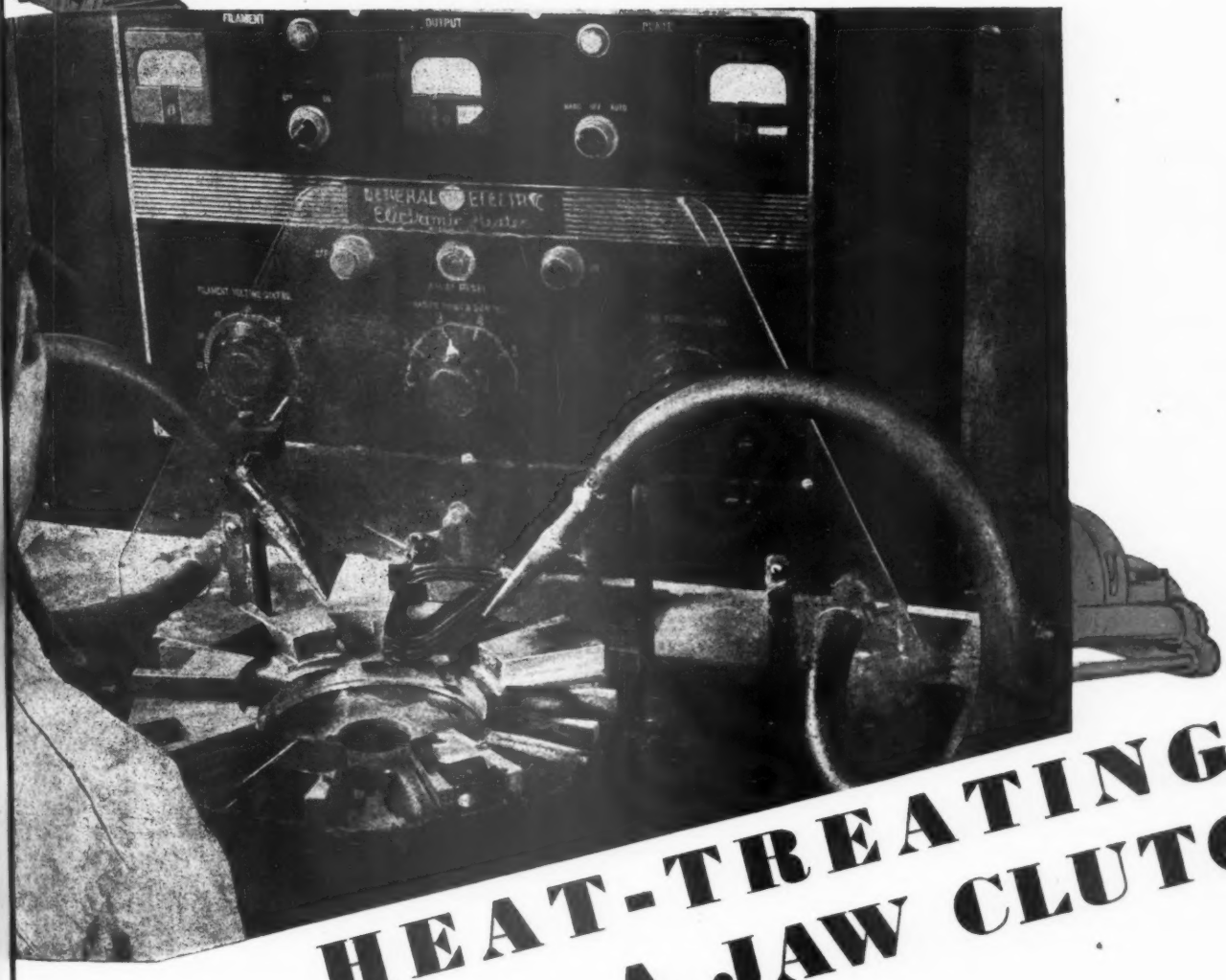

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TRENDS IN LIQUEFIED PETROLEUM GAS INDUSTRY AS REFLECTED BY SPECIAL SURVEY

By **PAUL K. THOMPSON**, *Chief*, Liquefied Petroleum Gas Section
Natural Gas and Natural Gasoline Division, PAW

THE continued use of liquefied petroleum gas as a fuel and a source of energy, together with its more recent application as a raw material in the production of aviation fuel, synthetic rubber, and chemicals, has placed this product foremost in the class of critical materials. Possibly the use of no other petroleum product has developed so rapidly as the separate fractions and mixtures of propane and the butanes. The greatly accelerated war use of LP-Gas was definitely confirmed during the winter months of 1943-44 when transportation difficulties, together with localized shortages, brought about by necessary diversion of products as war materials, precipitated the worst winter in the history of LP-Gas. Early in the spring of 1944, it appeared that a similar condition would be encountered during the winter of 1944-45. Thus, to make available all possible information relating to the supply and demand of LP-Gas, the Petroleum Administration for War requested industry representatives to determine as nearly as possible these conditions in PAW districts I, II, III, and IV for 1943, 1944, and the first six months of 1945. Similar information was already available for District V, that area embracing the states of California, Arizona, Nevada, Oregon, and Washington.

This paper will discuss the service performed by the Special LP-Gas Survey Joint Subcommittee in preparing this report, making available for publication such portions of this study as wartime security permits in addition to commenting on related factors such as government regulations, distribution, etc., endeavoring to analyze these factors in the light of what may be expected in the immediate future, together with the developments that may result with the return to normal times.

James E. Pew, director of the Natural Gas and Natural Gasoline Division, Petroleum Administration for War, called a joint meeting of the LP-Gas Subcommittees of PAW Districts I, II, III, and IV, which resulted in the organization of a Special LP-Gas Survey Joint Subcommittee. This committee consists of the following industry representatives:

G. R. Benz, chairman, District II Liquefied Petroleum Gas Sub-Committee, Natural Gas and Natural Gasoline Committee.

Louis Abramson, chairman, District III, Liquefied Petroleum Gas Sub-Committee, Natural Gas and Natural Gasoline Committee.

R. W. Leslie, chairman, District IV Liquefied Petroleum Gas Sub-Committee, Natural Gas and Natural Gasoline Committee.

W. A. Naumer, chairman, District I Liquefied Petroleum Gas Sub-Committee, Natural Gas and Natural Gasoline Committee.

E. M. Petersen, secretary, District II Natural Gas and Natural Gasoline Committee.

This committee was requested by the Petroleum Administration for War to ascertain as nearly as possible the relation between the supply and demand of liquefied petroleum gases for 1943, 1944, and the first six months of 1945 in the United States, excluding the West Coast (District V). In carrying out this request, a questionnaire was prepared by the committee for the purpose of procuring information on both the production and disposition of liquefied petroleum gases. To ascertain the actual and estimated potential production for the period in question, a form was developed, which when properly filled out gave the requested information for: (1) Propane[1], (2) normal butane, (3) isobutane, (4) butane-propane mixtures, and (5) normal butane-isobutane-butylene mixtures. In determining the disposition of products, a separate form for each of the above products was developed to indicate that amount for: (1) Fuel purposes[1], (2) chemical manufacture, (3) refinery use, (4) isomerization feed, (5) synthetic rubber components, and (6) potential excess production.

Resume of existing conditions, a look at the immediate future, an evaluation of industry's status in normal times.

Information was received from 189 separate companies—six companies did not reply in any way to the questionnaire or the follow-up communications. Industry response is more completely outlined as follows:

Companies supplying information for report—110 (representing 201 plants).

Companies contacted but to whose operations the questionnaire did not apply—73.

Companies not replying to questionnaire—6.

Total companies contacted—189.

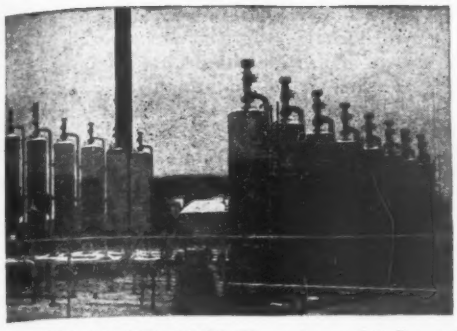
The information as supplied by the 110 companies representing 201 different plants was summarized and reported graphically by the committee. In addition, comments and recommendations are contained in the committee's report to PAW.

The release of the complete report at this time, in which statistics for the last nine months of 1944 are estimated, may appear to some as coming at too late a date to be of maximum value. On the contrary, PAW was continuously advised by the committee throughout the progress of the survey, and since the major portion of the work was completed during the summer months, the resulting information has been of invaluable help in planning for the present winter. It is quite impossible to enumerate here the difficulties encountered by the committee in conducting this study, these difficulties being directly responsible for the apparent delay in its final presentation.

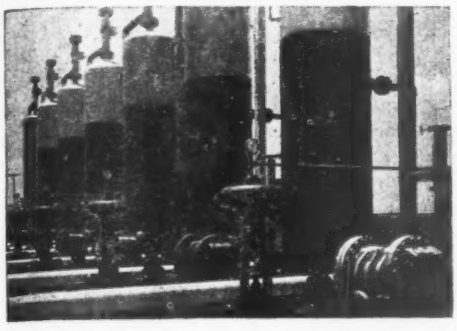
The LP-Gas survey covered only the production and disposition of products. Naturally, related problems such as transportation, manpower, and lack of equipment contribute to the success or failure of wartime distribution even though the required products are available in the field or refinery. It was decided to limit this study, as previously noted, and rely upon information presently available to industry concerning distribution. Shortly after this study was under way, it was evident that such a decision was correct because it was necessary for the committee to exert all its energy to conduct and complete this work even at a late date. The many problems encountered by the committee did not affect the quality of its first report. The successful manner in which these problems were solved is partly reflected in this splendid report, a portion of which is discussed herein.

In analyzing the relationship of supply and disposition of LP-Gas, widely different local conditions became apparent. Although such conditions contribute to the overall picture, any single condition is not necessarily representative of the entire situation as reflected by such a survey. Too, ever-changing problems of transportation and storage added to the

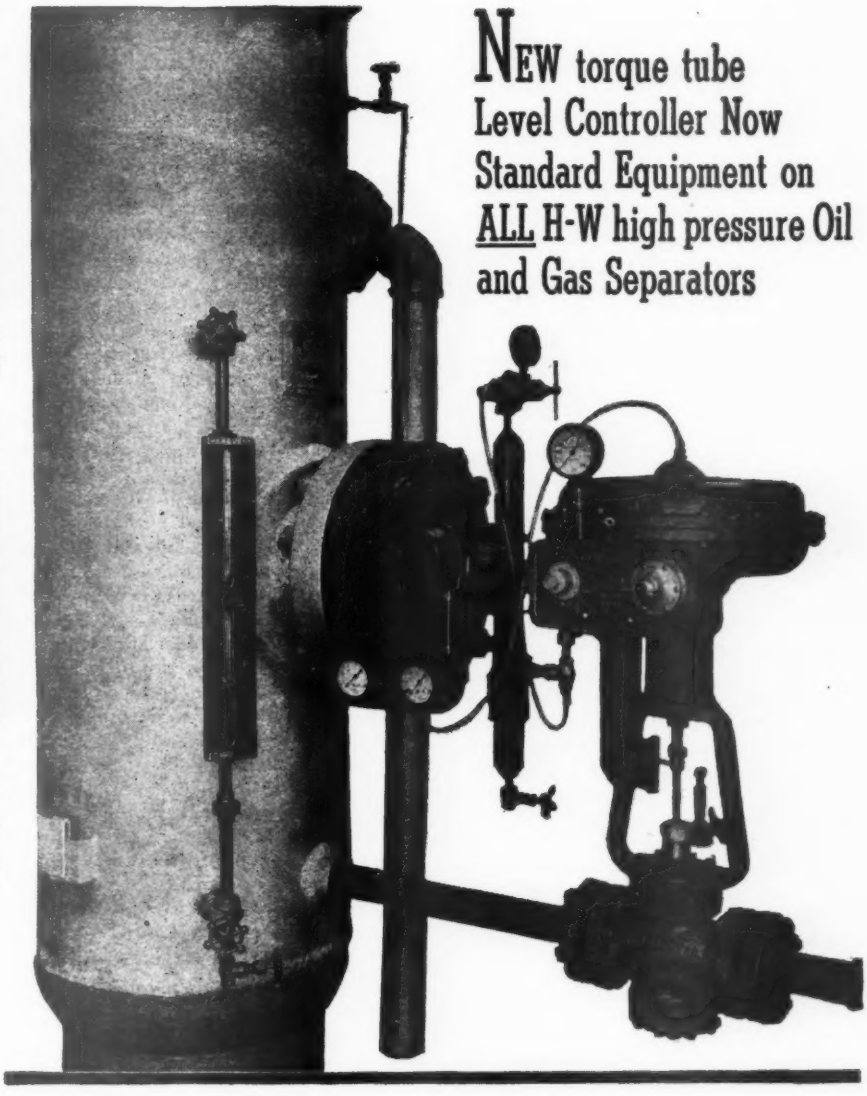
[1]Refer to glossary for definition of products and other notes.



ABOVE AND BELOW: Two views of 36" x 16' x 500 lb. H-W Type H-2 High Pressure Oil and Gas Separator Metering Installation.



AT RIGHT: Type 855 Liquid Level Controller consisting of 8" x 900 lb. Type 844 Torsion Tube Float Flange with Type 1411 Pilot. 2" x 600 lb. Flanged Globe C.F.B.O. Type 86-D Motor Valve. 2" Type 222-HD Drip; Type 303 Auxiliary Equipment Panel and Accessories.



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many other variables make the present LP-Gas fuel situation a problem of most difficult proportions. These variables dictate that the release of information relating to the total production and use of LP-Gas as fuel, would tend to distort the picture and result in false conclusions rather than to provide a basis for industry to solve its present problems. Accordingly, the use of LP-Gas as fuel is only commented on herein whereas its use as a chemical raw material for refinery operations and for synthetic rubber components is discussed graphically with actual and estimated yearly figures presented.

The growing trend of LP-Gas as a chemical raw material is shown in Chart 1. The major components, presently employed for chemical use, are propane and butane-butylene mixtures. This study indicates that a total of 110,895,000 gal. of LP-Gas, as a liquid, was used as a chemical raw material in 1943. The 1944 requirement is set at 159,788,000 gal., an increase of 44 per cent. It should be noted that these amounts are for that LP-Gas shipped as a liquid only. Larger amounts of these gases are delivered to chemical plants in the gaseous form by pipe lines. A recent estimate[2] of the quantity of LP-Gas used as a chemical raw material, delivered as liquid or gas in the United States, indicates that a total of 389,127,500 gal. equivalent was used in 1943. The 1944 requirement, with the latter nine months estimated, was set at a 478,022,000 gal. equivalent, an increase of 23 per cent. This chemical use of LP-Gas

[2]"Science in Natural Gas" by James E. Pew and Frank H. Dotterweich, Petroleum Administration for War.

CHARTS ARE BASED ON A REPORT BY A SPECIAL LIQUEFIED PETROLEUM GAS SURVEY OF THE JOINT PAW DISTRICTS SUB-COMMITTEE.

continues to grow with prediction of ever-increasing amounts of ethane-propane and propane-butane mixture as raw material in processes employing regenerative cracking and catalytic oxidation, respectively.

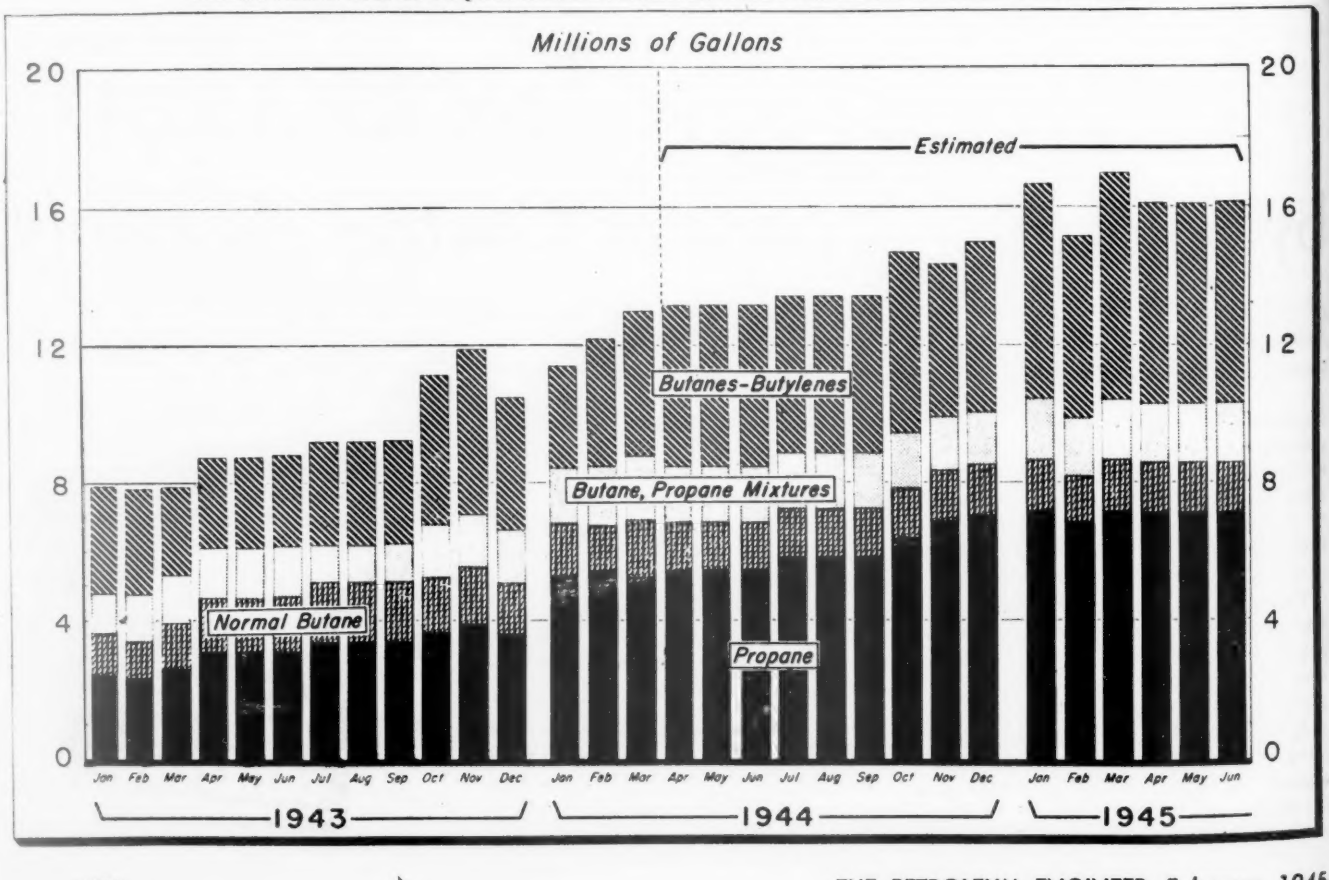
In the production of newer, better, and greater quantities of aviation fuel and to continue to meet essential military and civilian requirements of various fuels and other petroleum products, large quantities of LP-Gas are being used in refinery operations. In reporting the growing trend of LP-Gas for refinery uses (Chart 2) security restrictions have necessitated that this classification include not only conventional refining demands but those for isobutane for alkylation and butane for isomerization purposes. This is necessary to eliminate any possible prediction relating to increased alkylate production. Nevertheless, the increased use of LP-Gases for total refinery uses reflects their growing importance in the production of aviation fuel components. In 1943, 1,558,209,000 gal. of LP-Gas were used for refinery operations and 2,327,208,000 gal. estimated in 1944. This increase of 768,999,000 gal. (about 50 per cent) is of interest when compared with the total sales of LP-Gases in the United States for 1943 of 675,233,000 gal. as reported by the United States Bureau of Mines.[3] This large use of LP-Gas

[3]Mineral Market Report No. MMS 1204, U. S. Bureau of Mines, July 15, 1944.

in refinery operations can be expected until total victory. The termination of the war in Europe should not bring any reduction in the manufacture of key aviation fuel components such as isooctane alkylate, even though the total production of finished aviation fuel may be temporarily reduced until the concentration of the total war effort is established in the Pacific Area.

Another burden placed upon butanes is their wartime role in the production of synthetic rubber. In achieving the required production of synthetic rubber, which has been recognized by many as the outstanding chemical achievement of the war, enormous quantities of light hydrocarbon gases are required as raw material. The contribution of LP-Gas products is graphically portrayed in Chart 3. In the production of butadiene, one of the chief ingredients of synthetic rubber, large quantities of butane-butene mixtures are required. Thus, as in the case of isooctane alkylate, the production of synthetic rubber imposes large demands upon butanes. The survey reveals that 55,434,000 gal. of LP-Gas were required for synthetic rubber production in 1943 and 205,457,000 estimated in 1944, an increase of 270 per cent. Again, the future demands for LP-Gas products for synthetic rubber components are similar to those previously mentioned in the production of aviation fuel in that no reduction in their use can be expected until total victory in Europe and the Pacific. Even with total victory, the nation's synthetic rubber plants may be expected to continue maximum production to fill backlogs of civilian re-

CHART NO. 1. USE OF LIQUEFIED PETROLEUM GAS FOR CHEMICAL MANUFACTURE



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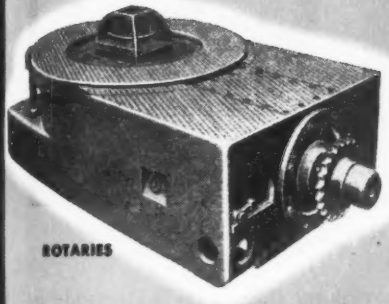
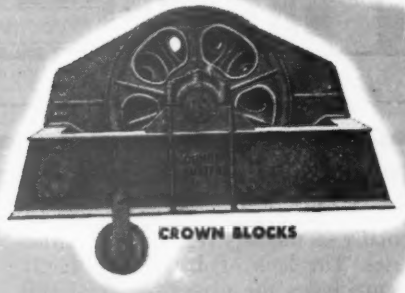


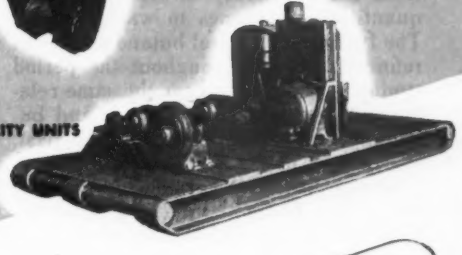
ROTARIES



CROWN BLOCKS

TRAVELING BLOCKS

SWIVELS



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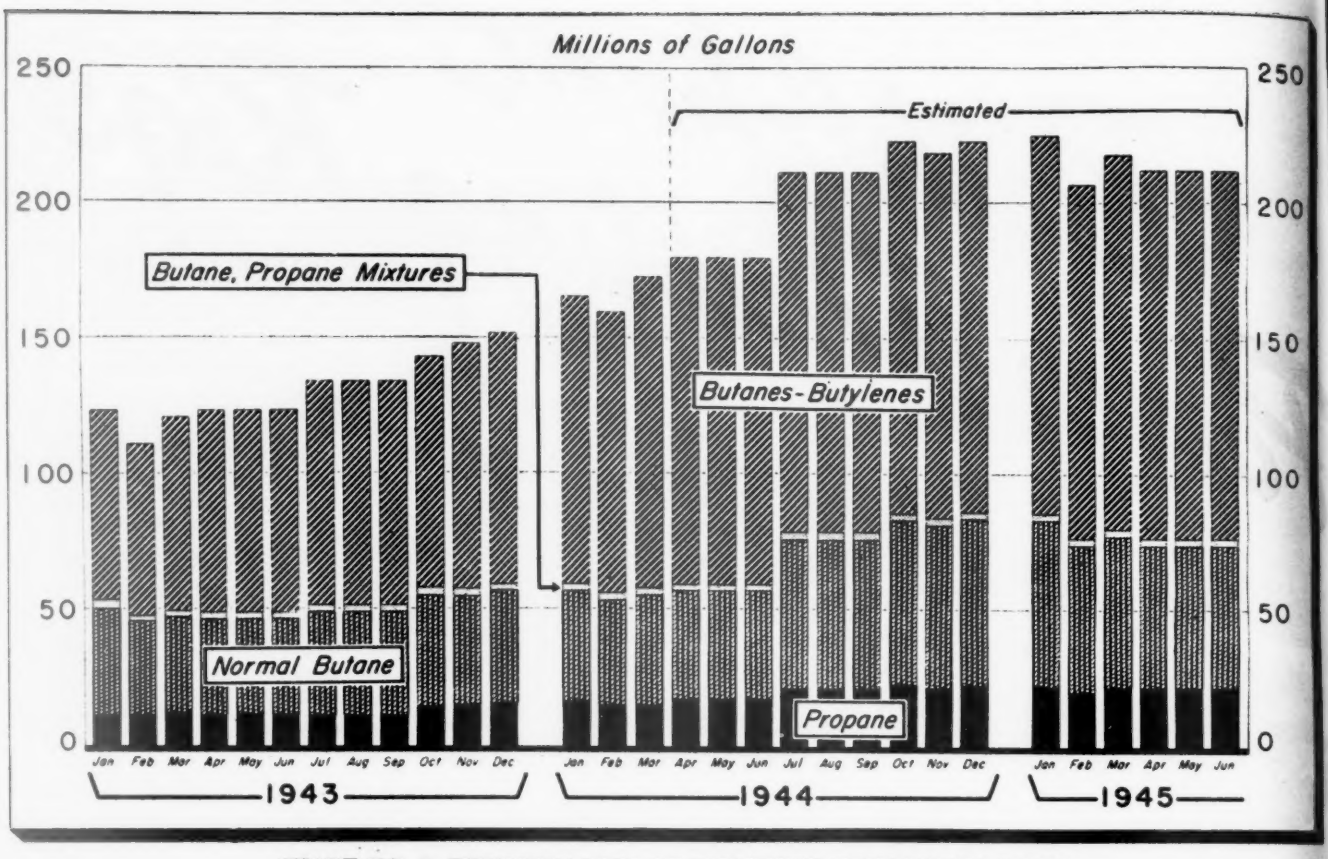

CHART NO. 2. REFINERY USES OF LIQUEFIED PETROLEUM GASES

quirements in addition to replacing large amounts of imported natural rubber until such time as natural rubber sources are once more revived and productive.

As mentioned above, statistical and graphical data will not be given for LP-Gas fuel uses. However, it is interesting to note that the survey clearly indicated a swing of significant magnitude to the predominance of propane over butane-propane mixtures for fuel uses. This abnormal relationship results, of course, from the temporary diversion of large quantities of butanes to war products. The fuel use of normal butane and spent refinery butanes throughout the period studied, continues to bear the same relationship to the use of propane and butane-propane mixtures, as in the past. The use of propane as fuel appears to have experienced the greatest increase of all LP-Gas fuels, mainly because of the diversion of butanes. Accompanying this increase are the conventional moderate seasonal fluctuations. The widespread use of butane-propane mixtures as heating fuels results in more pronounced seasonal demands than are evident in the use of any other LP-Gas product. The moderate increase in the use of LP-Gas products for fuel, other than butane-propane mixtures and the slight increase in the use of the latter, clearly reflects the results of the necessary steps taken by government and industry to insure the availability of these components for use in the production of vital war materials.

The well known fact that ample propane exists at production sources was indicated by the survey. As previously pointed out, the survey did not report factually on the very serious distribution phases. The lack of distribution facilities precludes the classification of this potential supply as available supply for actual consumer demands.

The critical butane and butane-propane situation of the past winter, together with that of the present winter, is definitely confirmed by the survey. It should be noted that the survey indicates a greater shortage of butane and butane-propane mixture for the winter period of 1944-45 than was experienced during the winter of 1943-44. The severity of the current shortages, as of December 1944-January 1945, of LP-Gas for fuel is the direct result of lack of transportation facilities, mentioned above, and also of the lack of butane, which was clearly predicted by the survey as early as the summer of 1944.

Although the entire report cannot be released at this time for war security reasons, it is hoped that industry will recognize the efforts of the committee and the value of the report submitted. The interest of industry in such surveys is timely, and it would seem to be appropriate for a continuation of these studies by industry on the return to normal times when war agency requests for such work will not be forthcoming. In anticipation of present LP-Gas problems continuing throughout the year of 1945 the Petroleum Administration for War has requested the Special LP-Gas Survey Joint Sub-Committee to continue the study for an additional period of time. It is contemplated to expand the proposed study to include PAW District V (West Coast) thus making the survey nationwide in scope.

For more than three years the operations of industry have been controlled and restricted by wartime regulations. The basic restrictions affecting the LP-Gas distribution industry are those embodied in WPB Limitation Order L-86 and Directions thereto. Broadly, Order L-86 prohibits the delivery and installation of equipment used to contain, distribute, or dispense LP-Gases. Direction 1 to Order L-86 restricts the delivery and acceptance of delivery of LP-Gas tanks. Direction 2 to Order L-86 prohibits the delivery and acceptance of delivery of LP-Gases for use as a motor fuel in private passenger automobiles.

The original purpose of Order L-86, when it was first issued April 8, 1942, was twofold: First, to conserve the then existing utilization equipment for the most important war uses; and, second, to conserve LP-Gas itself so that war demands could be met, and also, insofar as possible, so that the requirements of existing LP-Gas consumers could be satisfied.

As the demand for LP-Gas for use in the production of war materials increased, the primary function of Order L-86 became the conservation of LP-Gas, with the importance of equipment conservation becoming secondary but still quite necessary.

The administration of these regulations has attempted to accomplish the above purpose with a minimum of restrictions upon the industry. However, as the aviation gasoline and synthetic rubber programs progressed, with the

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resulting tremendous requirements for LP-Gas products, it became necessary to impose more restrictive measures. With the tentative report of the committee available in September, 1944, it was immediately evident that additional restrictions were necessary to meet the forthcoming conditions as predicted by the survey.

Thus, on October 24, 1944, the Petroleum Administration for War announced the issuance of PAW Directive 79. This directive prohibits the delivery or acceptance of delivery of butane for use as fuel in drilling operations where natural gas is available as a substitute fuel. This directive is effective during the present heating season November 1, 1944, to April 1, 1945. During this time the quantity of butane that will be available for drilling operations will be limited because of the demand for this fuel by domestic consumers during the winter months.

Further, the Petroleum Administration for War announced, by press release November 24, 1944, that as of that date PAW would be compelled to disapprove all applications to install equipment utilizing butane or butane-propane mixtures.

As indicated by the preliminary report of the committee and substantiated by their final report, there was a shortage amounting to 4 to 7 million gallons per month of butane for all uses. This shortage was immediately felt by the LP-Gas industry. With the cooperation of the refining Division of PAW, the necessary steps to alleviate this condition were taken to divert certain streams of mixed butanes from refinery use to LP-Gas fuel markets.

Ecuador raises output

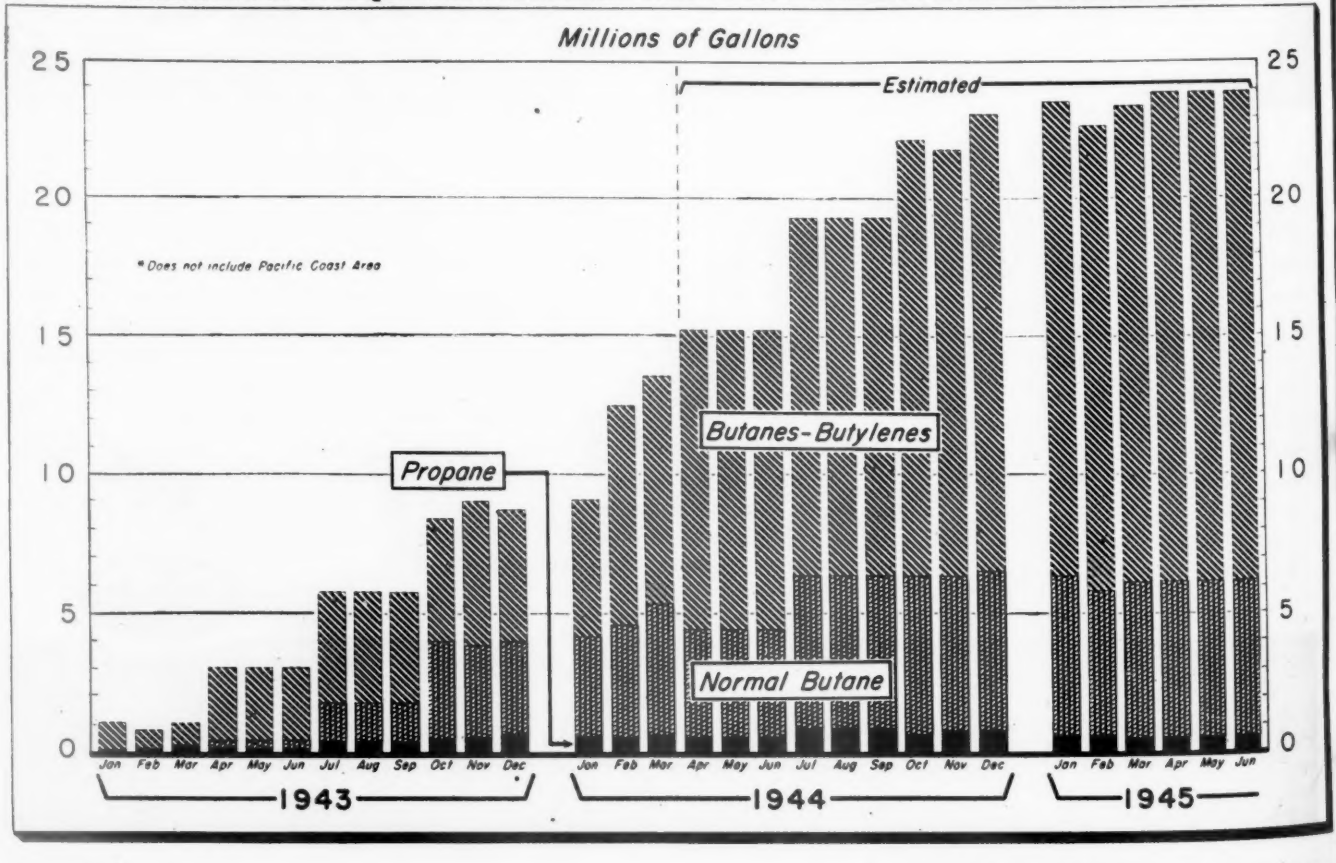
An 18.14 per cent increase in the production of crude petroleum in Ecuador was reported for the third quarter of 1944 in relationship to the same period for the preceding year. This represents a total production of 749,943 bbl. of crude for the third quarter, and an increase of 4.2 per cent over the second quarter of 1944.

Nearly 570,000 bbl. of crude petroleum were exported from Ecuador, principally to Argentina and Uruguay. Little more than 50,000 bbl. of gasoline were produced in the third quarter.

The present shortage of LP-Gas products, the result of wartime demands, is a widely discussed subject. These discussions are not, in general, restricted to present conditions but in many cases predictions have been voiced that these shortages will continue even after the return to normal times. Some visualize a propane shortage; others predict continued difficulty in obtaining the desired amounts of butane. The discussion herein relating to LP-Gas operations, on the return to normal times, is based upon an analysis of the survey committee's report, viewed in light of related information gathered in this division. The trend observed suggested that with the return to normal times, there will be a marked decrease in the demand for LP-Gas products that are now required for wartime fuels and raw materials. Accompanying that decrease will be an increase in use as conventional LP-Gas fuel, including the possible development and production of new fuels and for chemical manufacture. Thus, an ever-expanding LP-Gas industry appears to be assured. There should be ample supplies of propane and butanes to be used as economic conditions dictate, with increased supplies as needed, made possible by the availability of equipment for their production, transportation, storage, and utilization. As increased demands for LP-Gas products come about, production should keep pace with or possibly exceed market demands. Increased discoveries of natural gas and gas-condensate fields and the development of cat-cracking operations, together with modern extraction and separation procedures, apparently assure the availability of increasing amounts of light hydrocarbon fractions for LP-Gas products. In addition, these developments suggest production of sizable amounts of LP-Gas in locations where heretofore a long haul by tank car was necessary.

Diversified opinions have been voiced regarding the magnitude of demands that may be made of LP-Gas in its capacity as a chemical raw material when normal times return. Based upon present operations, which find butane-butene and isobutane as the key components for present chemical manufacture, when synthetic rubber and aviation fuel are included, there is a tendency to predict that butanes will be in such demand

CHART 3. USE OF LIQUEFIED PETROLEUM GASES FOR SYNTHETIC RUBBER COMPONENTS



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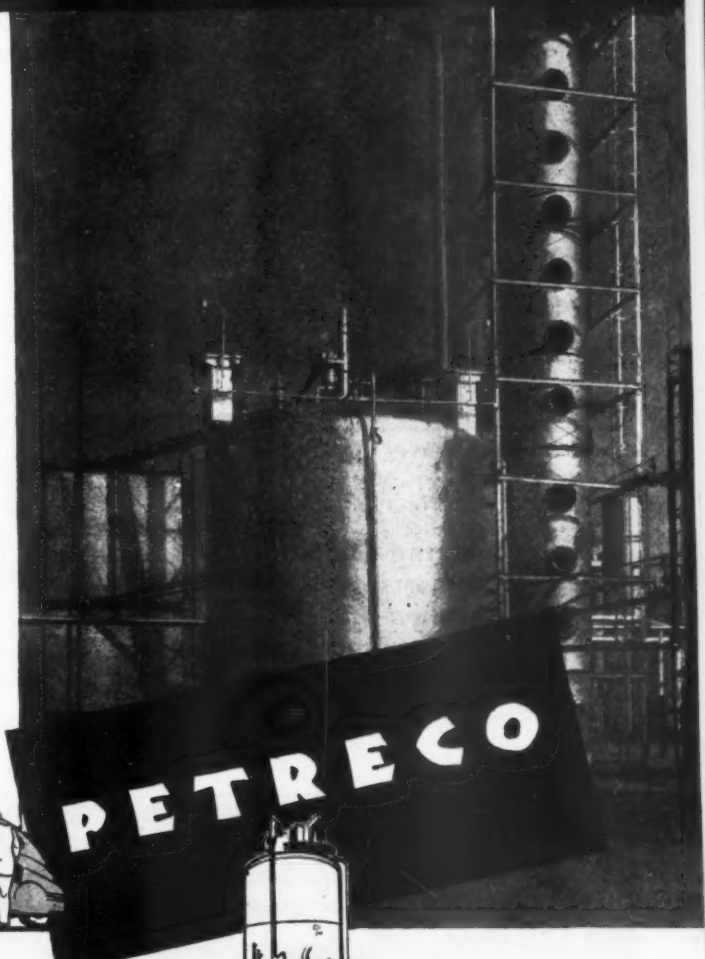

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that a general shift to the lighter product propane will be necessary for the expansion of the LP-Gas fuel industry. Rapidly changing conditions suggest that this supposition may not be entirely correct. In fact, some predict just the opposite; i.e., propane and not butane will be the key component for chemical manufacture. In analyzing this situation,[4] it must be pointed out that with the return to normal times the large quantities of butanes presently going into war material can be made available for peacetime uses. Too, we are now passing from an era of moderate thermal cracking into one in which intensified catalytic operations will predominate. Thus, where butane has been necessary to produce propylene in moderate thermal cracking, catalytic dehydrogenation will permit the use of propane as charging stock when the perfection of a satisfactory separation process is developed. In general, the present trend suggests that acetylene, ethylene and propylene will be the major components in tomorrow's chemical synthesis. The perfection of processes presently under investigation indicates the use of ethane and propane in ever-increasing quantities as raw materials for the production of these chemical components. Naturally, butane will be required as a raw material in many chemical operations, but this demand may not be as exhaustive as predicted by some. Therefore, the return to normal times should see a balanced demand for LP-Gas products, allowing this industry to expand and progress in a reasonably stable and desirable fashion.

In a paper[5] presented before an industry association meeting in New Orleans, September, 1944, the author cautioned against the difficulties presently experienced by the warning, "... In other words, your immediate program should be to prepare for the worst." This advice still holds true and even after the present heating season is past, the LP-Gas industry must continue a program that will enable it to meet its wartime responsibilities.

The difficulties now being encountered by the LP-Gas industry to meet its responsibilities may even become more acute. Nevertheless, these sacrifices and determined efforts of industry will not go unrewarded because these very experiences are creating an orderly, matured industry insuring a firm foundation upon which will be built tomorrow's modern LP-Gas industry, an industry fully exploiting its unlimited opportunities and whose stature in a relatively short period of time will compare favorably with that of other large industries.

[4]It is estimated that in 1944, LP-Gas used as fuel will be less than 20 per cent of the total LP-Gas used for all purposes.

Glossary

Propane. LP-Gas products containing 90 per cent or more propane and/or propylene.

Normal butane. L-P Gas products containing 90 per cent or more normal butane.

Isobutane. LP-Gas products containing 90 per cent or more isobutane.

Butane-propane mixtures. LP-Gas products containing more than 10 per cent propane and/or propylene.

Normal butane-isobutane-butylene mixtures. LP-Gas products not included in the above classifications.

Fuel purposes. Fuel purposes include the following: Continuous and standby uses for domestic, commercial, industrial, agricultural, and utility applications including but not limited to the following: Cooking, water heating, refrigerating, space heating, metal cutting, all kinds of industrial heating applications, gas manufacture, internal-combustion engine fuel, drying, baking, etc.

Chemical manufacture. Chemical manufacture includes products used as base materials or process feed stocks, additives, diluents, extenders, solvents for chemical manufacture or processing (except specific uses otherwise classified below), and for burning to make carbon black.

Refinery use. Includes all refinery use except that for isomerization feed stock. Includes LP-Gas used for refinery fuel and blending purposes.

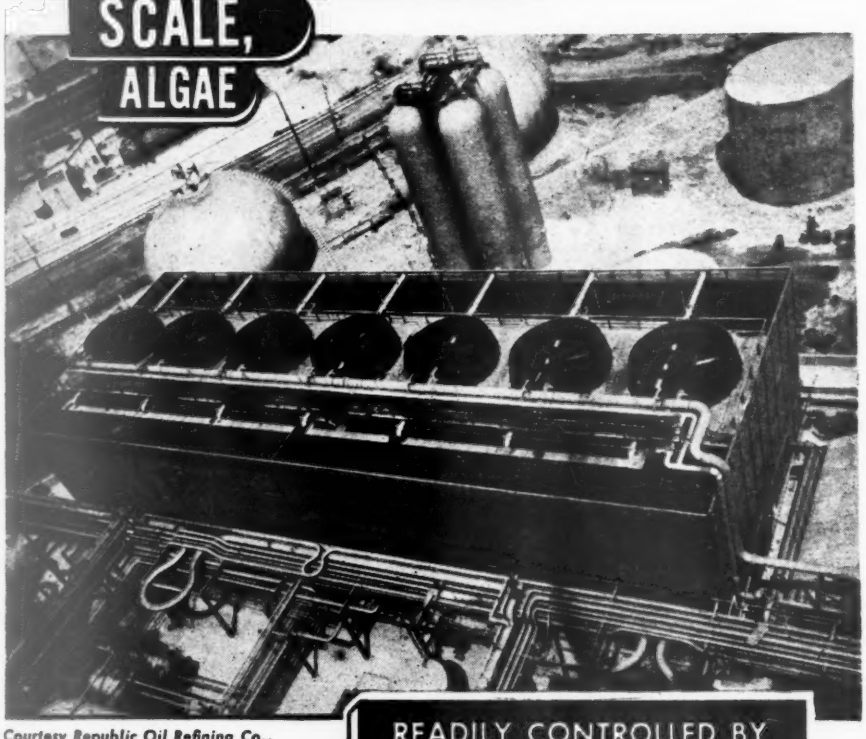
Isomerization feed. Includes all isomerization feed stock uses.

Synthetic rubber components. Includes all products to be used for processing into or manufacture of synthetic rubber components.

Potential excess production. Products not going into the above uses. ★★★

[5]"Will We Weather the Winter" by Paul K. Thompson, Petroleum Administration for War.

CORROSION,
SCALE,
ALGAE



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BIG PIPE LINE FOR BRITAIN

GEOFFREY LLOYD, parliamentary secretary of Britain's ministry of Fuel and Power, recently issued the following statement:

"To meet the needs of the Allied forces, Britain has had to be made into a great military oil dump. It has not only been a question of importing petroleum in quantities never previously approached or imagined, but once here, oil must be rapidly discharged, distributed, and stored.

"Since 1941, we have constructed in Britain an elaborate, interconnecting pipe line system a thousand miles long, and studded with scores of secret underground storage tanks, capable of holding large reserve stocks. It is a wholly British achievement—British in conception, planning and execution; the work of British engineers, employing British-made material and British labor.

"Already, no less than 2,400,000,000 gal. of oil, including hundreds of millions of gallons of aviation spirit, have been carried to the principal centers of consumption, especially airfields. Without pipe lines, the build-up of the Allied air offensive to anything like the desired scales would have been impracticable, and the problem of providing the huge petrol needs of the Allied invasion armies would have been greatly complicated.

"The work on the pipe lines has gone on with great cheerfulness day and night all the year round, often in bitter weather and in water-logged ground. Every difficulty was overcome because of the pressing military need, and every branch of the line has been completed on time and in many instances before schedule."

During recent months 5,000,000 gal. of petroleum were transported daily. The pipe line cost about £7,000,000 ($28,000,000) and 80,000 tons of steel were used in its construction.

One reason for its construction was the great increase in the quantity of oil that had to be transported due to the presence in Great Britain of the U. S. Eighth and Ninth Air Forces. It has also facilitated the delivery of more than 383,050 liquid tons of petroleum products that the British War Office made available to the U. S. ground forces, under reverse lend-lease, between January 1 and June 30, 1944. It is reasonable to suppose that 50 per cent of these quantities went toward the operational stockpile for the invasion of France.

Although the ever-growing needs of the RAF were in mind, the first part of the network to be laid down was a line to link the southwest oil ports with the London area. This pipe line was not intended for aviation spirit, but it would supply help by leaving the British railways free to carry the increasing quantities of aviation spirit needed by RAF Bomber, Fighter, and Coastal Commands. The terminal depot opened on December 5, 1941, six months after the preliminary work on the line had begun.

The next section of the plan was the linking in of the oil ports of the northwest coast, and this was achieved by a pipe line from this area running southwards to join the first line.

Facilities for pumping in either direction were provided and storage depots were linked into the pipe line. In the event of damage to either west coast oil terminal, supplies, with an additional line, were available and could be pumped from the north or south, and the eastern area was thus provided with two sources of supply. This second line was operational on May 30, 1942.

For the needs of D-Day, the next move was to make these new facilities available by linking in what were to become invasion bases. In the early summer of 1942, a spur from the original line was run to the south coast. Forty miles of the line, begun May 1, began operating June 30.

Up to this point, the system had enabled the British railways to deal with the rapidly growing demand by the RAF for aviation spirit, by relieving them of carriage from west to east of tens of millions of gallons of gasoline and paraffin. But further pipe lines were needed to handle the enormous increases in aviation spirit requirements of the RAF and AAF based in Great Britain.

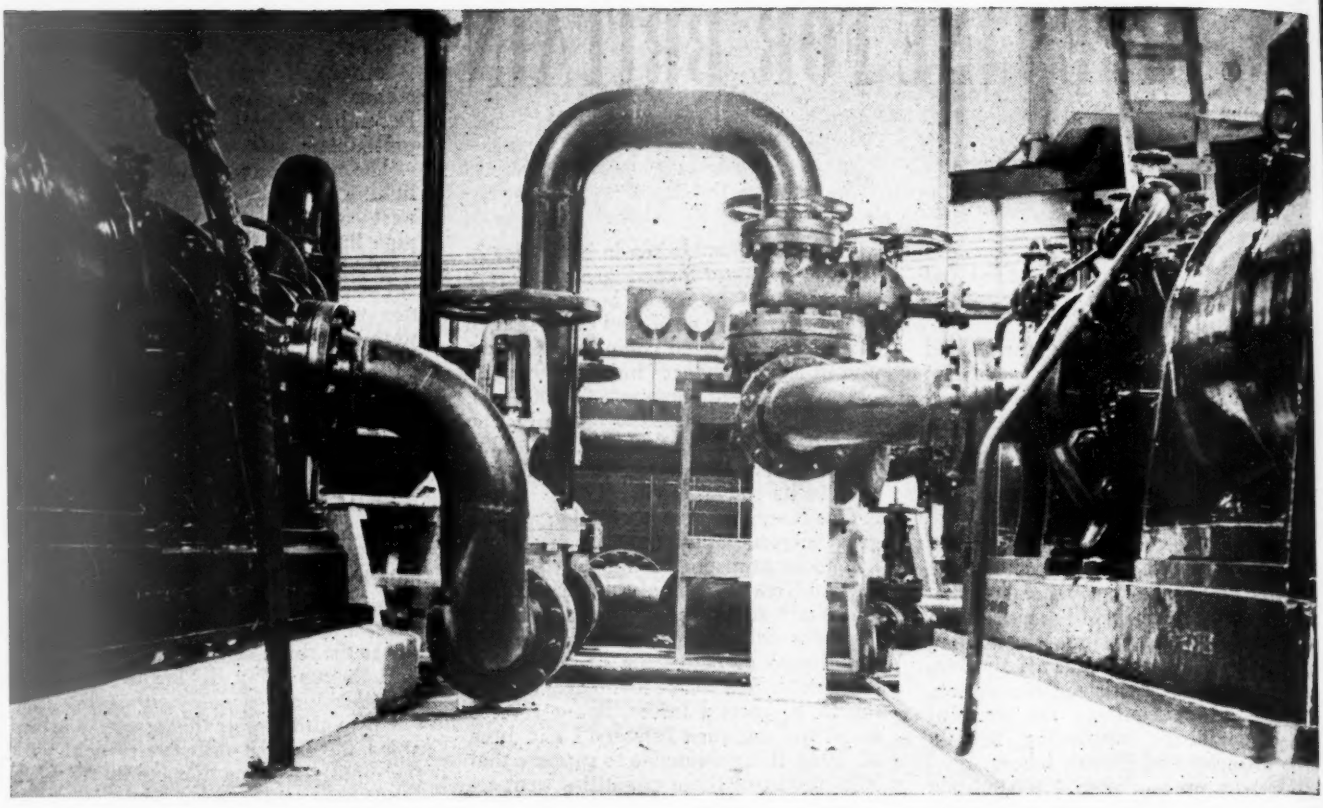
A big bomber offensive was beginning, and to prevent a lack of the fuel needed to sustain this offensive, the British Oil Control Board decided upon a new series of pipe lines to carry the aviation spirit from west coast ports to depots within easy reach of the great new airfields, already built or then building.

The plan provided for lines running from the west coast ports handling incoming tankers. These lines linked up to form an aviation spirit circuit more than 350 miles in length. In constructing this line, all types of country were traversed. One part of the line crosses terrain well over 1000 ft. above sea level. Work on the circuit began on October 1, 1942, both lines from the western ports began operating in March and the circuit was completed by the end of August, 1943. A considerable number of important storage depots were linked into the circuit and it is now the life line of the air arm stretched from this country to pound the Reich.

In the autumn and winter of 1943, further extensions to the pipe line system in the south and east of England were undertaken, partly to meet special air force needs and partly for the continental requirements of the Allied armies. The shortest of these extension lines runs for 22 miles and the longest for about 120. Another is nearly 100 miles in length, and all were in operation by the middle of March, 1944.

The method of organization worked out for the original line was so successful that it was used in the construction of all succeeding pipe lines. The route of

Pipe line being laid through the English countryside.



Above—Inside one of the oil pumping stations.

Right—Pipe line being laid across main road.

the line to be laid was broken up into a number of equal sections with a view to carrying on the work at equal speed in all sections, with completion to be reached simultaneously. Each section was a self-contained unit with its own engineers, land officer, labor force, and mechanical equipment. The allocation of materials as they became available and the delivery of the pipe to each section proved the most critical job. On this depended the equal progress of every part of the line throughout. Speed was the keynote, but quality of materials and workmanship were of paramount importance.

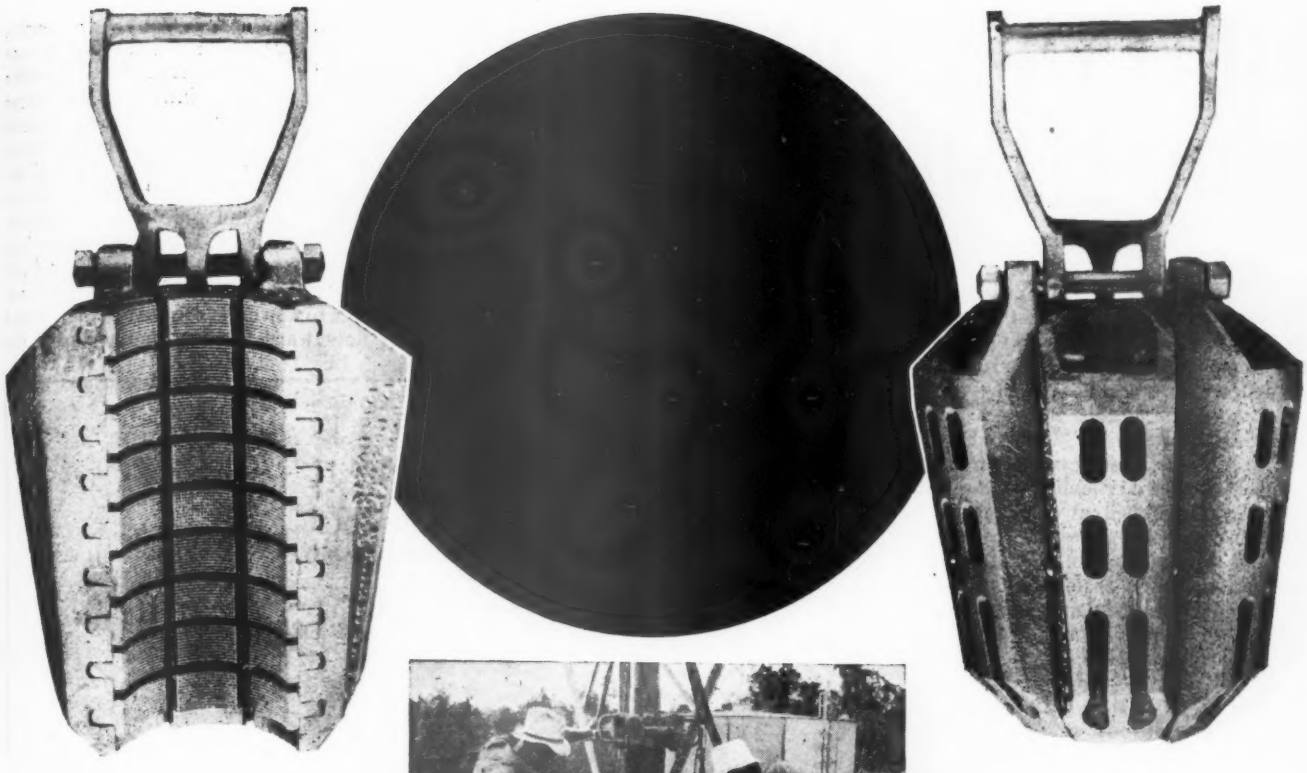
Routes were chosen across the open country wherever possible so that the fullest use might be made of mechanical excavators. Agricultural interests were closely watched. On an average, a swathe of ground 15 to 20 ft. wide only was affected, and this only for a comparatively short time. In trenching, the top soil was removed and kept separate from the subsoil so that on completion the top soil was again replaced on top of the trench, and farming could continue uninterrupted as soon as the laying of the line was completed.

Many physical difficulties—water obstacles and rivers by the score have been crossed, ranging in size from large tidal estuaries, middle reaches of substantial rivers, to upper reaches of those rivers into small brooks and drainage ditches a few feet wide. With the enormous demand for steel for all war purposes, speed of laying was limited by deliveries of pipe from the mills.

The maximum amount of pipe laid in one week was 18 miles of 10-in. line. The best sustained effort was 125 miles of both the 10-in. and 8-in. in 84 days. More than one-half the system consists of 8-in. pipe and more than one-fourth of 10-in. The short stretches of spurs consist of 12, 8, or 4-in. pipe. Virtually all the pipe lines are designed to work at a pressure of 600 lb. per sq. in. This pressure enables comparatively light steel pipe to be used, and thus large quantities of steel were saved.

In normal construction, every joint in the pipe line is "butt welded." Britain's pipe-line system had to be built without welders, as none could be spared from the shipyards. In place of welded joints, special couplings were used. These allow a certain amount of expansion in length in the line. Where only welded joints could stand the strain of pressure, "anchors" are used—these anchors are small concrete piers through which the lines run at points where it bends, and relieve the joints of all abnormal strain. The pumps used are nearly all of the centrifugal type driven by electric motors. To maintain efficiency and prevent the formation of rust, scrapers and brushes run through the lines at regular intervals. In the initial construction, arrangements were made whereby these "go-devils" can be introduced and removed from the lines. Filters have been installed at intervals along the system.

Before it was used by oil, the pipe line was tested with water at considerably over working pressure, and "go-devils" were sent along the entire length. The entire length of the system is under a continuous patrol. This constant inspection insures a never-ceasing flow of oil through the great pipe-line system across Britain. ★★★



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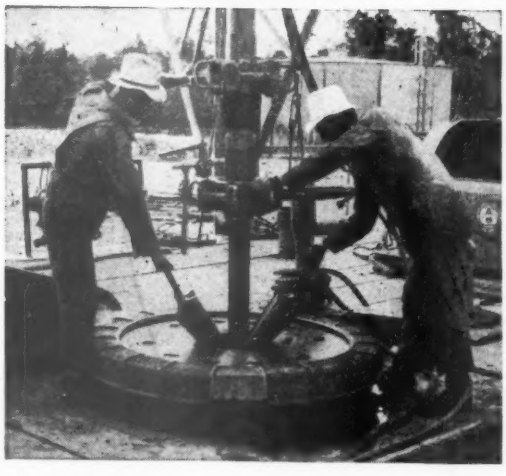

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DIRECTION CONTROL IN REDRILLING OPERATIONS

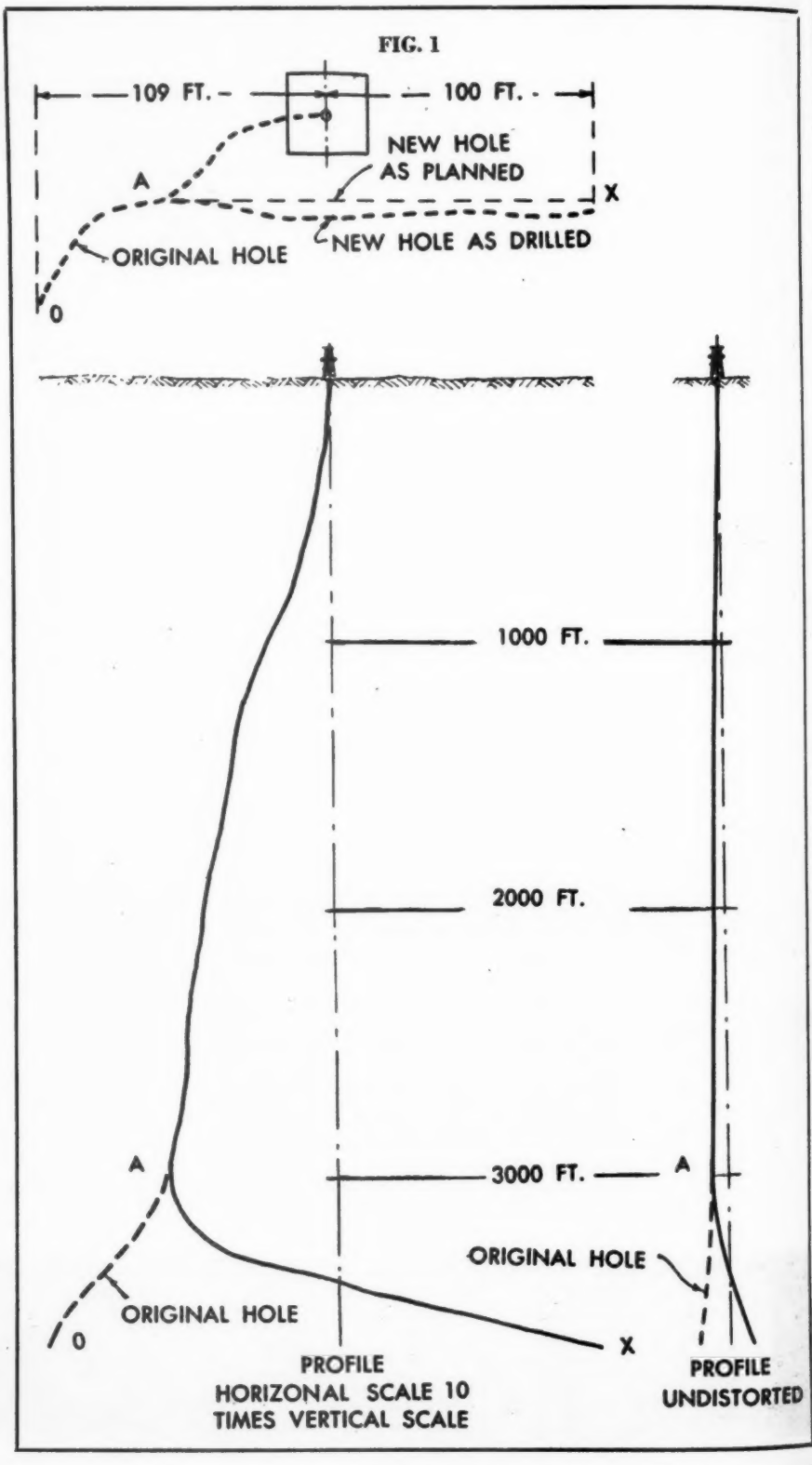
By **WALLACE A. SAWDON**
Pacific Coast Editor

EXCLUSIVE In many instances the object of recompletion work is to move the bottom of the well a considerable distance from the original location on the sand in order to drain more thoroughly the area being produced by the well. Many old wells that were drilled before much attention was paid to the verticality of the hole have been bottomed at horizontal distances ranging from a few feet to as much as a quarter of a mile from the surface location. It is impossible to estimate even an approximate average distance to which wells have deviated and it is only from wells that have been surveyed that the wide differences in deviation can be appreciated. In some areas structural conditions cause a uniform drift in both direction and angle; in others, surveys have shown adjacent wells to have deviated in different directions and at varying angles of inclination. When the bottom is at any appreciable distance from the surface location the well is not draining its particular area equitably and when recompletion is found desirable the new portion of the hole should, in most cases, be drilled with direction control to penetrate the productive zone at the most advantageous point. In some instances where the new hole is to go in a direction opposite to that of the original well bore, depth is lost when taking off from the old hole. A new method of starting downward with a vertical arc has, however, been the means of reversing direction directly.

In determining the new sand location several factors have to be considered. The old hole must, of course, be surveyed to determine the actual course of the bore below ground and the information thus obtained can be used to select the most advantageous point at which to start the new hole. The production and maintenance records will provide valuable data on downhole conditions but other considerations to be taken when establishing the new bottom location include amount of depletion, porosity and permeability of the formation, lenticularity, remaining gas content of the fluid, water intrusion, direction of drive, structural position (especially position relative to productive limits of pool), well spacing and locations of bottoms of adjacent wells. Property lines may influence the selection of bottom location in offset wells and in some cases information regarding the locations of bottoms of the offset wells may not be available.

The point of departure from the old hole is sometimes not so carefully considered as it should be. Although the least amount of new hole possible might seem most desirable it may sometimes be economical to start the new hole higher up the well and avoid trouble in control while drilling the new hole. The survey will throw considerable light on how the formations tend to influence the course of the hole. The maximum angle desired obviously will influence the distance above bottom at which the point of departure is to be located. The presence of cement behind pipe and the protection of upper zones may have to be taken into account. Even the direction and angle of the original hole may make it advisable to move the starting point upward or downward a short distance from the

FIG. 1



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one determined by other factors. No dog-legs should, of course, be permitted under any circumstances and anything that will prevent their possible occurrence can be considered an economical procedure.

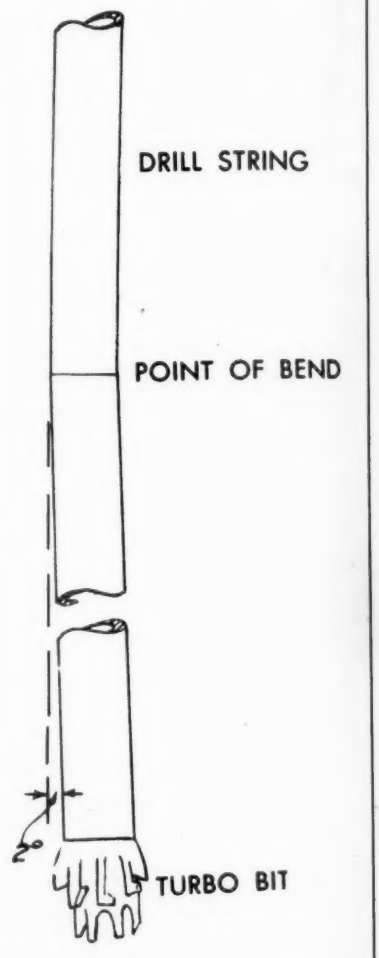
With the point of departure and the desired location of bottom established, the usual procedure of recompletion is followed. If casing is in the hole and conditions make it desirable to plug off the old hole below the starting point of the new hole, it will be advisable to cement behind the pipe as well as to deposit a plug within the casing or liner. This assures that the entire hole is plugged and no migration of fluids will occur through the annulus. The plugging can be done by gun perforating and squeeze cementing through the perforations. An adequate window is milled, usually with a whipstock oriented at position.

Controlled directional drilling is then employed to carry the hole from the point of departure to the predetermined location in the productive zone. Removable whipstocks or knuckle joints are generally used to change direction or angle when either or both are necessary, these tools being oriented into the well to establish or maintain direction. Single shot survey instruments are run at specified intervals to check the angle and direction of the uncased hole and to provide data for corrective measures if the hole begins deviating from the course intended. The single shot also provides records for plotting the course of the bore as it progresses.

A recent innovation for starting the new hole off was recently used by one company in recompleting one of its old wells in a California field. Data on the operation or survey records of the well cannot be disclosed but the procedure followed is illustrated by Fig. 1. It was desired almost to reverse direction of the well from a selected point and to bottom the new hole at a desired location in the sand without losing depth by the operation. To do this it was necessary to start off with a vertical arc and then carry the hole directly to the predetermined bottom location.

Referring to Fig. 1, the point "A" in the well used for illustration was selected as the point of departure from the old hole, which had been previously surveyed. The desired bottom location determined from the various factors was at "X," which lay due east from the point of departure and at a distance of 100 ft. from the north-south centerline of the surface location. The average drift angle necessary to drill the new hole as planned was computed to be 14 deg. and the maximum angle required after the vertical arc was drilled was found to be a little over 20 deg. The distorted profile of the well shown below the plan indicates the details of how the vertical arc was formed. The undistorted profile to the right in Fig. 1 shows how gradually the arc was drilled and how free of dog-legs the new hole was. The actual direction of the new hole and how closely it followed the proposed course is indicated in the plan.

FIG. 2



To make the vertical arc without losing depth a turbo bit developed for horizontal drilling[1] was used.

This bit is rotated by the drilling fluid and no rotation of the drill string is necessary for its operation. The drilling mud used for power is circulated by the mud pumps and is maintained at a suitable viscosity for operating the bit.

Instead of the flexible drill pipe with which the turbo bit is used for horizontal drilling, the lower 8 ft. of the bottom joint of the drill pipe was bent to an angle of 2 deg. with the pipe above and the bit attached to the bottom of this bent section as shown in Fig. 2. The string was then oriented into the hole so that the bit would start off in the predetermined direction. After the bent section of pipe had penetrated the formation, the drill string was pulled. The direction and angle of inclination were then checked with the single shot and the hole carried to completion by the usual controlled directional drilling methods, being completed within a few feet of the predetermined bottom location. ★★★

[1] "Horizontal Drilling is Tried in Partially Depleted Fields," The Petroleum Engineer, August, 1944.

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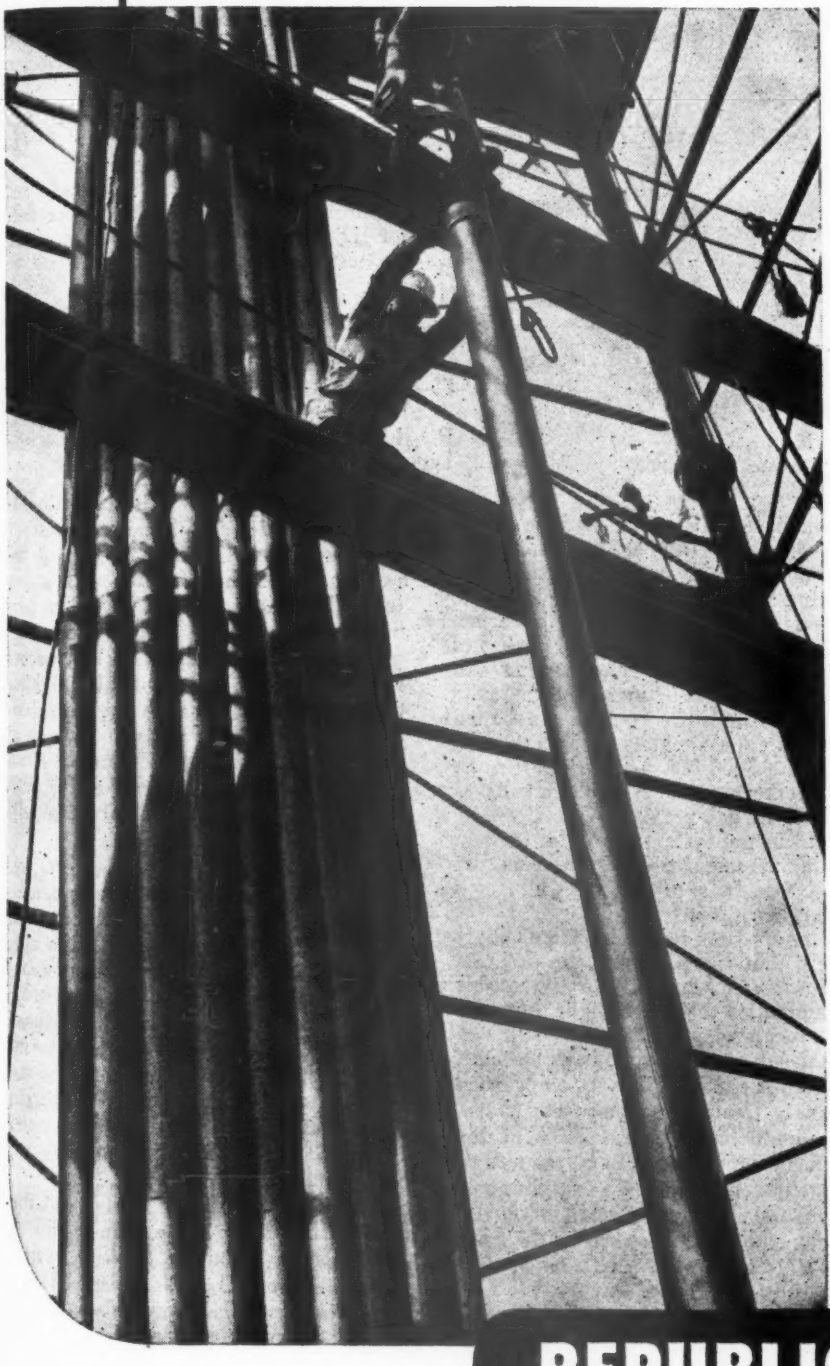

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THE FRACTIONATION OF HYDROFLUORIC ACID AND ITS SIGNIFICANCE IN HF ALKYLATION

By **RANDAL MAASS**, *Refinery Engineer*
General Petroleum Corporation of California

EXCLUSIVE ANHYDROUS hydrofluoric acid is usually prepared from commercial 60 per cent HF by direct fractionation in a packed copper or copperlined tower. Reboil is provided by direct application of heat to the bottom of the tower and reflux by a condenser situated at the top. The diluent in 60 per cent HF is water contaminated with sulphuric and fluosilicic acids.

The regeneration of HF used in the alkylation process may be accomplished in a manner analogous to that used in its preparation. The principal differences in the two processes arise out of the entirely different nature of the contaminants. The purpose of this article is threefold:

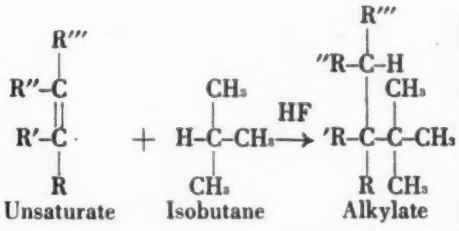
1. **To enumerate the contaminants in alkylation HF and perhaps speculate in some cases on their origin.**
2. **To point out the effect of these contaminants on the design of the HF regenerator as contrasted to the simple column used in the HF preparation.**
3. **To point out the importance of maintaining a reasonably low contamination in the acid.**

Contaminants in alkylation HF. *Water.* It is quite generally conceded that HF is one of the most hygroscopic substances known. Consequently, any moisture coming into the acid system is readily absorbed by the acid. To prevent this contamination water condensing and cooling systems are all operated at pressures below the acid system pressures so that in the event of a leak the transfer would be acid to the water system. A continuous pH recording of these waters immediately advises the operator of a leak and permits an early rectification. Barring any mishap the principal source of water is the entering hydrocarbon feed stream. Through careful drying of this stream, first by means of a salt tower and second by means of a bauxite tower, the moisture content can be reduced to approximately 10 ppm. On the basis of a 5000 bbl. per day charge, the water entering the system amounts to 10 lb. or 1.2 gal. per day. With 83,000 lb. of acid in the system the water content should increase by 0.012 per cent per day. It can be seen that the water contamination is not excessive.

Sulphur. It is becoming increasingly evident that HF has great desulphurizing powers. Consequently, to prevent this contamination the feed stock is prepared as an overhead product leaving the elemental sulphur in the column bottoms. The feed is then caustic washed or caustic-tannin treated to remove the hydrogen sulphide and mercaptans. With this treatment the sulphur can be reduced to approximately 50 ppm. The sulphur carried into the system amounts to 50 lb. per day and, if all absorbed by the acid, represents an acid degradation of 0.06 per cent per day.

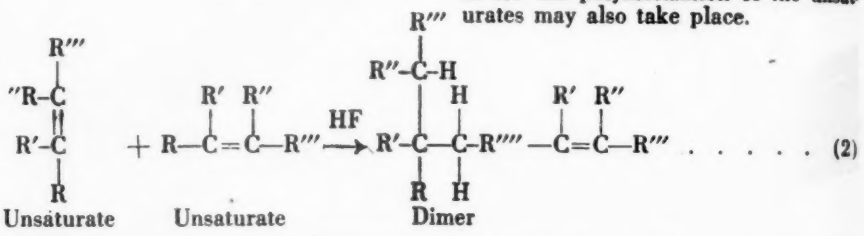
Hydrocarbons. It is to be expected that the hydrocarbons would be somewhat soluble in the acid phase. Semi-quantitative studies have shown the presence in the acid phase of all the saturated hydrocarbons present in the system from methane through alkylate. In addition, considerable quantities of heavy hydrocarbons including tarry materials have been found. To speculate as to the origin of these heavy oils, a review of the basic reactions might be advisable.

The reaction desired in alkylation is the following:



. . . . . (1)

That is, a reaction of isobutane and an unsaturate is desired. In the presence of HF the polymerization of the unsaturates may also take place.

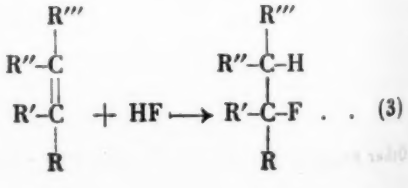


. . . . . (2)

As the dimer still contains a double bond, trimers (and higher polymers) may also form. In addition, any of the polymers could be alkylated with isobutane. To make the first reaction predominant, an excess of isobutane is supplied to the reactor by recycling excess isobutane to the contactors. By making this excess very large, in the neighborhood of 500 mols. of isobutane to one of unsaturate, the statistical chance of an unsaturate contacting another unsaturate before contacting an isobutane will be very small.

It also appears that the second reaction is reversible, for the dimer can be added to alky plant feed to be converted to aviation alkylate along with the normal feed. Presumably, the second reaction reverses to supply the unsaturate for the first reaction. In alkylating the dimer the heavy oil formation appears to increase, which lends credence to the theory that polymerization is the origin of the heavy oils. In any event, heavy oils are found in both the acid and hydrocarbon phases.

Organic fluorides. An analysis of the hydrocarbon phase of the reactor effluent shows a fluorine content in excess of that present as free HF. It is presumed this fluorine is the molecular combination of HF and an unsaturate somewhat as follows:



. . (3)

RANDAL MAASS studied chemical engineering at California Institute of Technology where he obtained his B.S. degree. He has a M.S. from the University of Southern California. In 1934 he joined The General Petroleum Corporation of California as a laboratory assistant in the gas department, later serving as an assistant to the superintendent. In 1943 he was transferred to the refining department as a refinery engineer to assist in the 100-octane program.

Whether this combination is a necessary step in the alkylation or whether it represents a side reaction, of course, is not known.

The analysis also of the acid phase after neutralization shows an unsaturate content out of proportion to its solubility. Presumably, these unsaturates are released from organic fluorides in the neutralization by a reversal of reaction No. 3.

Recapitulation. To recapitulate, four principal contaminants are found in the HF acid, water, sulphur, hydrocarbons, and organic fluorides. The latter two, hydrocarbons and organic fluorides, contribute the bulk of the contamination in approximately equal quantities. The first two, water and sulphur, represent only a small percentage of the contamination principally because their entrance into the system is rigidly controlled. As would be expected, these contaminants are distributed between both the acid and the hydrocarbon phases. However, in the case of water and sulphur, the equilibrium is predominantly in favor of their absorption in the acid phase.

Effect of contaminants on the design of the regenerator. To study the effect of the contaminants on the design of the acid regenerator, we will take the simple column used in the preparation of the acid and modify it as required.

The amount of contamination will have a considerable effect upon the design since it will size the column. It is possible to keep the acid in a satisfactory state of purity by daily charging a quantity equal to 50 per cent of the acid in the system. As the circulation is some 100 times greater than this, the regenerator charge then need be only a drag stream. Nevertheless, if the entire charge must be redistilled every two days, the task is of a considerably greater magnitude than is the task of the acid preparation. Consequently, the regeneration tower must be built on a larger scale. In large scale operations it is difficult to supply sufficient reboil heat by means of a heater of a size that could be placed in the tower bottom. Second, the high boiling tarry contaminants, under some conditions, make it difficult directly to reboil the bottoms. Many operators have circumvented these difficulties by supplying the major portion of the column's heat requirement to the feed. However, it has been difficult to combat the corrosion prevailing in the acid preheater. On the other hand, we have found it feasible to supply the heat by a forced circulation type reboiler in which the tower bottoms are pumped through an exchanger and returned to the tower. The heat is picked up partially by the latent heat of the lighter components and partially by the sensible heat pickup of the heavier components. As the bottoms are relatively free of acid (less than 0.2 per cent HF) the corrosion in this type heater is less serious, but by no means absent.

In the original design of HF alkylation plants, it was felt that the principal contaminant would be the high boiling tarry compounds that could easily be separated from the acid. Under this assumption, the problem resolved into one of stripping the bottoms free of acid. This mode of operation, as might be expected from our discussion of the contaminants, resulted in the failure to remove the lower boiling contaminants, which continued to build up in the acid; that is, only the heavy tarry compounds could be removed. In this connection it might be noted that the organic fluoride boils considerably lower than does the unsaturate from which it was formed. That is, fluorides of high boiling unsaturates could also escape removal in this mode of operation. Therefore, to separate the HF from the compounds boiling in the vicinity of the HF boiling point, a rectifying section and reflux is required. Although a simple condenser on top of the column could be used, it is possible to employ the azeotropic nature of the acid to facilitate the separation. Isobutane and HF form a constant boiling mixture (CBM) of the minimum type; that is, the CBM boils lower than either of the components or any other of their mixtures. Therefore, if any gaseous mixture of HF and isobutane is progressively cooled, the condensate and the vapor will both eventually reach the CBM composition and remain there. The remaining condensate then formed will of necessity also be of the CBM composition. In rectification this means that the progressive cooling up the column can lead to the formation of the CBM. By refluxing the

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tower then with isobutane, the HF is removed in an azeotropic combination with isobutane at a lowered boiling point at the same time that the contaminants are rectified from the combination. In this manner 99-100 per cent acid can be obtained overhead with less than 0.2 per cent acid in the bottoms. It might be added that isobutane reflux is taken from the isobutane recycle stream upstream of the rate controlling motor valve and the HF-isobutane tops mixture discharged without the aid of a pump downstream of the motor valve, the pressure across the valve being sufficient to overcome the pressure drop through the vapor line and condenser. The pressure drop is kept at a minimum by using a motor valve on the liquid tops only, the column pressure being controlled through the action of this valve in flooding the condenser bundle situated directly above the accumulator.

To prevent a high fluorine loss, it is necessary to break up the organic fluorides into HF and unsaturates, that is, to reverse equation No. 3, rather than permit them to be removed with the bottoms. As heat is an effective means of reversing equation No. 3, the continued reheating of the bottoms afforded by its recycle through the heater serves to insure a low fluorine content. Analysis of the bottoms shows a fluorine content of less than 0.1 per cent. It can readily be seen that the fluorine content is sufficient to supply HF for the acidity of approximately 0.2 per cent. The difference, of course, could be explained by the presence of other acids. Despite this analytical ambiguity, it can be deduced from these data that very little fluorine as organic fluorides remains in the bottoms.

The presence of water in the acid feed contributes to the corrosion problem and some means must be employed to combat it. Recognizing the multicomponent nature of the feed, the simple two component relationship between HF and water is used in this discussion because of the absence of other adequate data. HF and water, like HF and isobutane, also form a constant boiling mixture (CBM), the composition being 55 per cent acid. The HF-water CBM, however, is a maximum; that is, the CBM boiling point is higher than that of the HF, the water, or of any of their other mixtures. This means that the progressive heating of any HF-water mixture will eventually result in the liquid and vapor attaining the CBM, the final vaporization taking place at this composition. Applying this reasoning to the material fed to the acid regenerator, the acid-water mixture in the feed will become progressively heated as it passes down the tower and will therefore approach the HF-water CBM. That is, just as the HF and isobutane at the top of the tower tend to approach the HF-isobutane CBM, the HF and water at the bottom of the tower tend to approach the HF-water CBM. Insofar as these three components are concerned, the column is trying to separate the HF-isobutane CBM from the HF-water CBM.

The CBM is the most corrosive of the HF-water mixtures. Other mixtures become less corrosive as their composition is removed from the CBM. Therefore, the mixtures in the vicinity of the CBM should be avoided if possible. It can readily be seen that if the stripping and heating action is not carried too far, the CBM need not be reached in the bottom of the tower. If the water content is not too high, this condition does not represent an excessive loss. Considering the 0.2 per cent acid cited as in the bottoms, a total bottoms of 20,000 lb. per day (including flushing oil to the bottoms cycle pump) yields a 40 lb. per day acid loss. This figure together with the 10 lb. per day of water to be removed indicates a terminal acid concentration of 80 per cent. On the other hand, if the fluorine analysis is used to indicate the HF content of the bottoms, the terminal acid concentration obtained is 68 per cent, which is dangerously close to the CBM. As the data upon which these concentrations are based are only approximate, not too much confidence can be placed on the computation. Nevertheless, it indicates that the small amount of acid present may not have reached the corrosive CBM.

Even though the CBM may not be reached in the tower, it is quite likely to be attained during the heating process in the forced reboiler. Consequently, the corrosion tendency would be expected to be greater in this piece of equipment.

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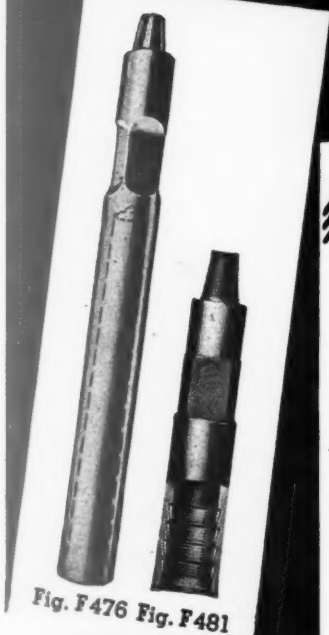

Fig. F476 Fig. F481

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(Fig. F 476)
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(Fig. F 481)

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Some designers have further felt that the heating and vaporizing of the acid, separate and apart from the formation of the CBM, is in itself a corrosive process. For this reason attempts have been made to feed a vaporized acid to the tower to remove the bulk of the vaporizing job from the tower to a more accessible and replaceable piece of equipment. The use of an exchanger type of feed preheater has resulted in severe corrosion of this equipment. We have found it feasible to prevaporize the feed by admixture with a recycled bottoms stream in an enlarged section of the feed line just prior to its entry into the column. By this method it is hoped the dilution will serve to protect the feed line from corrosion. In addition, it was felt the increased oil on the trays might offer some additional protection. Note that prevaporizing the feed does not materially change the CBM relationships in the column previously discussed. The cooler section of the tower will condense an HF-water mixture rich in HF, which will have to be stripped out of the bottoms as previously discussed.

From the above discussions it can be seen that the corrosion tendency in an acid regenerator is quite severe. Because of the lack of any definite knowledge regarding materials that could best withstand this corrosion, our first tower and auxiliaries were fabricated entirely from a low carbon steel. Observations on this equipment showed that the corrosion was most severe at the bottom two plates with some corrosion in the reboiler and the bottoms pumps. This indicates that perhaps the CBM is at least closely approached in the bottom of the tower. The vaporizing section of the feed line, contrary to our expectations, showed only a small amount of corrosion. As might be expected, the upper part of the column, the condenser, and the accumulator showed no appreciable metal loss.

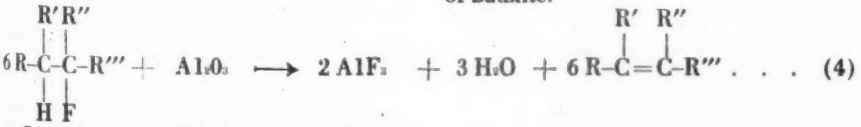
From test strip data obtained during 6 months of operation, monel was selected as the material best suited to withstand this corrosion. This conclusion is corroborated by other operators' experience. Note that the presence of sulphur rules out the possible use of copper or silver, a conclusion also verified by other operators' experience. To provide this protection a new monel lined tower, equipped with monel trays and caps, was installed. In addition, the bottom cycle pumps were provided with monel runners, and the valves (globe) in the hot oil system were provided with monel trim. Monel lined heads are also on order for the reboiler bundle, and some consideration is being given to monel tube sheets. To date, after 90 days of operation, the monel tower has not been inspected. The monel in the valve trim and pump runners has given excellent service.

Importance of low acid contamination. It appears that the principal effect of a high acid contamination is the increased formation of organic fluorides. The organic fluoride concentration in the hydrocarbon stream has been found to be a direct function of the acid concentration in the acid to the contactors. Also, the rate of acid contamination increases with increased contamination. It is presumed that this contamination, too, is organic fluorides. The additional regenerative effort required is the least of the difficulties therein encountered. The increased organic fluoride content of the hydrocarbon stream provides the greatest difficulties.

In our process, the hydrocarbon stream out of which the acid has settled is first stripped of its remaining free HF content in an acid stripper. The heating in the acid stripper reboiler also serves to break up some of the organic fluorides. The stream then passes to the deisobutanizer where very little organic fluoride breakdown occurs because of the relatively lower reboiler temperature. The stream is next treated in a bauxite treater in which the major portion of the remaining organic fluoride content is removed. The following debutanizer effects a small additional breakdown; whereas, the subsequent second stage bauxite treater removes the last traces of organic fluoride. To complete the flow, the alkylate including the isopentane is rerun to remove a small percentage of heavy alkylate.

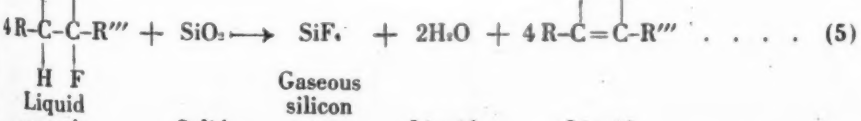
The troubles encountered in high acid contamination are centered in the first stage bauxite treater and in the debutanizer immediately following. To understand better the origin of the difficulties, the reactions in this treater will be reviewed.

The principal reaction takes place between the organic fluorides and the aluminum oxide, the major constituent of bauxite.



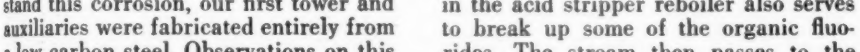
Liquid organic fluoride	Solid aluminum oxide	Solid aluminum fluoride	Liquid water	Liquid unsaturates

A secondary reaction occurs between the organic fluorides and minor constituent of bauxite, silica.



Liquid organic fluorides	Solid silica	Gaseous silicon tetrafluoride	Liquid water	Liquid unsaturates

Considering the products of the reactions, the solid aluminum fluoride, of course, remains in the bed. The liquid unsaturates are included in the outlet hydrocarbon stream. The water at the treating temperature (200° F.) is not completely absorbed, especially after the bed approaches saturation, and a portion is carried out with the hydrocarbon. The gaseous silicon tetrafluoride too is carried out with the stream. Any of the unsaturates that are butenes will appear in the normal butane and will represent a loss of potential alkylate. The heavier unsaturates will appear in the alkylate to degrade the knock numbers; whereas, the heaviest unsaturates will appear in the heavy alkylate, which may also represent a potential alkylate loss. By far the most deleterious results, however, arise out of the silicon tetrafluoride and water contents of the stream. These two constituents of the stream find their way to the debutanizer condenser at which point, under the influence of the lowered temperature, reaction No. 5 is modifiedly reversed as follows:



Gaseous silicon tetrafluoride	Liquid water	Solid silica	Liquid hydrofluoric acid

. . . . . (6)

The consequences of this reversal are a plugging of the condensers and tower with silica and corrosion of the equipment by the HF and remaining water.

As water is a necessary component of this reversal, lime has often been added to the bauxite bed to retain the moisture. This has been only partially successful and then only at low fluoride contents. As temperature aids the fluoride removal, any attempt to improve the effectiveness of the lime would defeat the primary purpose of the treater.

The addition of a continuous alkaline wash to flush the silica from the condensers while neutralizing the HF has proved more satisfactory. The pH of the effluent water stream must, however, be controlled within narrow limits to prevent corrosion on the one hand and the loss of copper from the tubes on the other.

No means has proved quite so effective in combating these difficulties as has the maintenance of a low contamination in the acid to the contactors. By maintaining this contamination in the neighborhood of 3 to 5 per cent, that is with an acid strength of 95 to 97 per cent, the troubles resulting from the removal of the organic fluorides are materially reduced. A slight silica deposition and HF corrosion is still present but insufficient to warrant washing and neutralization. In addition, the unsaturate loss is commensurately reduced.

An additional loss, not heretofore mentioned, arising out of a high fluoride content to the bauxite treater, is the loss of bauxite as well as the time required to empty and refill the case. ★ ★ ★

Haglund resigns

Announcement has been made by J. C. Axelson, president of the Axelson Manufacturing Company, pioneer Los Angeles manufacturer, of the resignation of A. G. (Abe) Haglund, formerly vice president in charge of lathe sales.

Haglund has been with Axelson for more than 33 years and during that time has become widely known throughout machine tool and petroleum industry circles as a part of the Axelson sales organization.

Abe has traveled the world for many years as expert sales manager for Axelson deep oil well plunger pumps and similar equipment. At the outbreak of the war, and the subsequent curtailment of the export market, Haglund took charge of sales for Axelson's line of heavy duty engine lathes.

His resignation, effective from the first of 1945, results from his desire to go into business for himself, having become affiliated with the Griffin and Ross Machinery Company, Los Angeles representatives for Axelson lathes.

W. H. (Jack) Jackson, also an old time member of the Axelson organization, has been appointed to replace Haglund as chief of foreign and domestic lathe sales. Jackson first joined Axelson in 1908 as a machinist, and since that time has been shop foreman, purchasing agent, plant manager, divisional sales manager, and most recently in charge of procuring and expediting vital war materials in connection with production of Axelson lathes.

Jackson will be working under the supervision of Alvin Zwerneman, general sales manager for Axelson.

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Dr. Anderson resigns

Dr. R. P. Anderson, affectionately known as "Andy" to his friends and associates in the petroleum fraternity, has retired, after more than 20 years' service, to become a resident of Chester County, Pennsylvania, it has been announced by President W. R. Boyd, Jr., of the American Petroleum Institute. Dr. Anderson has been technologist on the staff of the institute and secretary of the division of refining.

R. P. Anderson
—*Underwood and Underwood Studios, New York.*

"Andy" was born and reared in Wayne County, western New York state, where he prepared himself for his early career as a student and professor of chemistry at Cornell University, Ithaca, New York. After 13 years at Cornell, he moved to Oil City, Pennsylvania, to become chief chemist for the United Natural Gas Company. After 7 years with that company, he resigned to become API technologist.

Joining the institute's staff in June, 1924, he began a career of service that long will be remembered by those in the industry who have participated in technological activities relating to petroleum —not only within the institute, but also in the American Society for Testing Materials, American Standards Association, Coordinating Research Council, Inc., International Standards Association, National Fire Protection Association, and other organizations.

As secretary of ASTM committee D-2 since June, 1925, Dr. Anderson took an important part in the development of standard methods of test and specifications for petroleum products and lubricants.

As secretary of the joint API-ASME committee on unfired pressure vessels, he provided the means through which the API-ASME code has achieved its present standard of acceptance.

As secretary of the institute's division of refining, Dr. Anderson carried out the recommendations and plans adopted by the general committee of the division of refining, and administered the activities of the numerous divisional committees and subcommittees engaged in automotive research, meeting programs, standardization of equipment, testing methods and specifications, and vocational training.

Finally, Dr. Anderson served as secretary of the advisory committee on fundamental research on the composition and properties of petroleum, which sponsors

research projects under the institute's expanding program of fundamental research.

For the immediate future Dave Stroop will serve as acting secretary of the division of refining.

Montrose resigns

M. E. Montrose has resigned as director, vice president and manager of service and sales of Lane-Wells Company, and has left the company, according to an announcement by Walter T. Wells, chairman of the board of directors.

J. D. Hughes will hereafter head the sales department with the title of sales manager.

Miss B. G. Peters has resigned from the board of directors but will continue in her position as secretary-treasurer with no change in duties.

Two new directors have been elected to the board. They are: Melvin H. Hass, administrative and executive assistant to the president, Adel Precision Products Corporation; and S. M. Wagner, division manager, Los Angeles division, Ethyl Corporation.

Head Bartlesville station

The reassignment of N. A. C. Smith, supervising engineer of the U. S. Bureau of Mines Petroleum Experiment Station at Bartlesville, Oklahoma, and the transfer of H. C. Fowler, assistant chief of the Bureau's Petroleum and Natural Gas Division, Washington, D. C., to the position of Bartlesville supervising engineer is announced by Dr. R. R. Sayers, director of the Bureau.

In appointing Smith to a position of special assistant to the supervising engineer to handle specialized research and technical writing, Dr. Sayers paid tribute to the faithful services rendered by him in administering the Bartlesville Station, which has been expanded and developed under his direction to its present important place as an institution for petroleum research. The reassignment was made at the request of Smith.

The newly appointed supervising engineer, H. C. Fowler, has been a member of the Petroleum and Natural Gas Division for 21 years. Born in California and graduated from Stanford University, he was employed by California oil companies for several years before joining the Bureau in November 1923. After serving at the Bartlesville station, he was transferred to Washington in 1927.

Before entering the services of the Bureau of Mines, Smith was engaged in industrial chemistry work for about six years. He entered the Petroleum and Natural Gas Division of the Bureau in August, 1918.

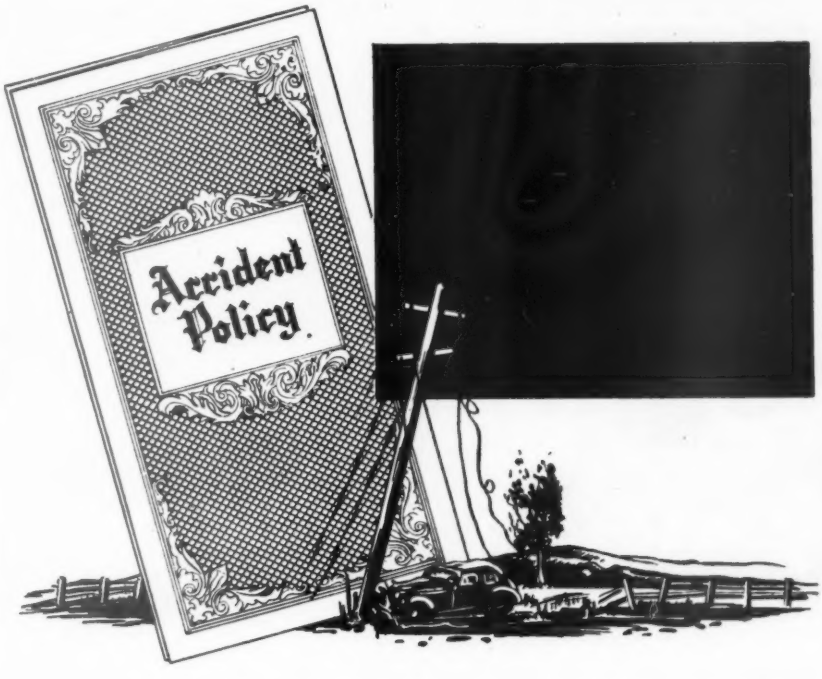
Competent, reliable man, twenty-five years experience as drilling superintendent on cable tools, wishes position with reliable firm or company. Details and references on inquiry. Address Box 22, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

To petroleum committee

David Proctor, secretary and assistant general counsel for the Gulf Oil Corporation, Pittsburgh, has been appointed a member of the American Petroleum Industries Committee, it is announced by President W. R. Boyd, Jr., of the American Petroleum Institute.

Proctor was born in Cuero, Texas. After being graduated by the Tome Preparatory School, Port Deposit, Maryland, he entered the University of Texas, and was graduated with an LL.B. degree in 1915. With his brother, Venable Bland Proctor, Jr., he practiced law in Victoria, Texas, until the entry of the United States into World War I. Rejected for active service because of underweight, he was offered, and accepted, the position of special agent for the Bureau of Investigation, Department of Justice, acting a year in that capacity. Later he was accepted in the Intelligence Department of the U. S. Army, serving until the end of the war.

In 1919 Proctor resumed his law practice in Victoria, but in a few months joined the legal staff of the Gulf in Fort Worth. In 1937 he was transferred to Pittsburgh, and was elected secretary of the Gulf Oil Corporation and its domestic subsidiary companies. He still serves in that capacity. On January 1, 1943, he was appointed assistant general counsel of the corporation.



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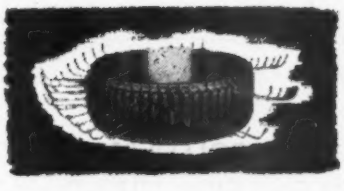

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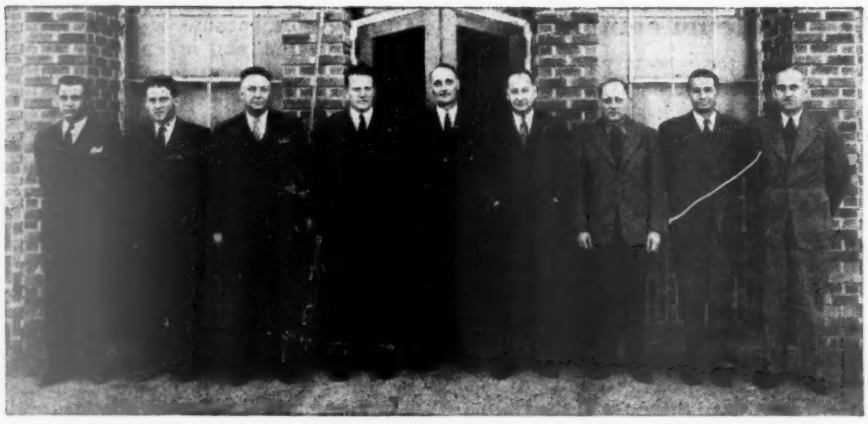


Reading from left to right: W. A. Adkins, L. R. Van Aradale, A. I. Shurtleff, R. R. Bush, F. A. Arnesen, W. R. McLaughlin, J. T. Cottrell, D. D. Collins, and M. D. Gilbert.

Representatives Meet

The annual conference of service engineers covering the Tulsa territory for Pittsburgh Equitable Meter Company-Merco Nordstrom Valve Company was held at the company's branch offices and warehouse, in Tulsa, December 12, 13 and 14, 1944. Sessions were presided over by M. D. Gilbert, district manager. Those attending are shown in the accompanying photograph.

Chief research engineer

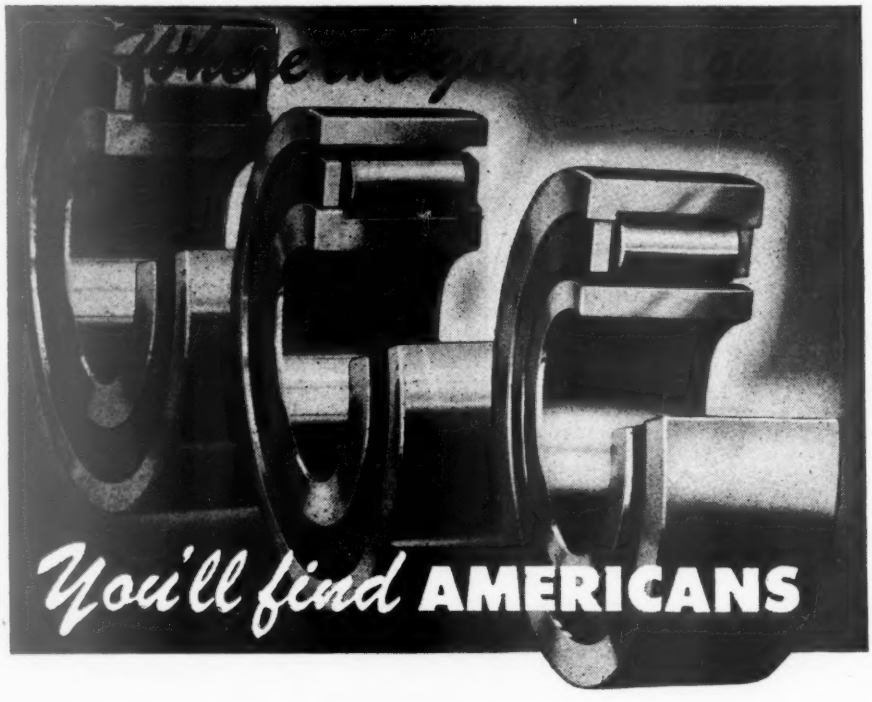
J. D. Mattimore, director of research and development for Tube Turns, Louisville, Kentucky, announces the appointment of Arthur R. C. Markl to the post of chief research engineer. Before joining Tube Turns, Markl for 14 years was associated with the M. W. Kellogg Company, New York, last in charge of the development of equipment for oil refineries. He is a graduate of the Technical Institute of Munich and a member of the American Society of Civil Engineers.

A. R. C. Markl

"E" award

For "great accomplishment in the production of war equipment," American Meter Company's Philadelphia plants were awarded the Army-Navy "E." The presentation was made to the employes at Town Hall, Philadelphia.

Norton McKean, president of American Meter Company, presided as chairman. In his brief acceptance address, William G. Hamilton, Jr., assistant manager in charge of the Philadelphia factories, stressed the loyalty and patriotism of fellow workers whose efforts had brought recognition by the war and navy departments, drawing attention to the fact that for 106 years the organization had concentrated upon the development and manufacture of meters, and that their production goals on war work had been achieved through complete conversion of equipment and retraining of skilled meter makers and the employment of additional workers.



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Heads Girdler Corp.

George O. Boomer has been elected president of The Girdler Corporation, Louisville, Kentucky, succeeding Walter H. Girdler, Sr., who died on January 7. Boomer will also remain vice president and a member of the board of directors of the firm's affiliate, Tube Turns, Inc. He was a close friend and business associate of Girdler for many years.

G. O. Boomer

Boomer has been a member of the board of directors of The Girdler Corporation since it was founded, and executive vice president since 1938. He was formerly vice president of the Ewald Iron Company and president of the Pittsburgh Fuel Company.

He is a director of the Louisville branch of the Federal Reserve Bank of St. Louis, Ewald Iron Company, the Louisville Industrial Foundation, and the Louisville Board of Trade.

Sparks appointed

Cummins Engine Company, Inc., Columbus, Indiana, manufacturers of diesel engines for automotive, industrial, and marine applications, has announced the appointment of F. W. Sparks as manager of the Cleveland region, with headquarters at 805 Fidelity Building, Cleveland 14, Ohio. This region includes Ohio and Michigan.

F. W. Sparks

Sparks has been a member of the Cummins sales department for several years, most recently having been at the home office.

Operators meet

Nearly 60 technical representatives of petroleum producers employing the Houdry fixed-bed catalytic cracking process met in St. Louis, Missouri, January 18-19 for a general discussion of the process and methods to increase the production of aviation gasoline for the war effort. The meeting was a closed session held with the approval of the Petroleum Administration for War.

Supply center

Something really new in the way of a combined industrial and residential housing project, restricted exclusively to oil field supply and equipment companies, is the unique supply row development at Houston, which has already excited the attention of architects nationally.

Running from Hughes Street to Wayside Drive, and two blocks south of Harrisburg Boulevard in Houston's industrial east end, supply row is situated on a beautifully wooded tract of 60 acres near the Hughes Tool Company and other important oil field tool and equipment manufacturers. A portion of the tract bordering Country Club Bayou has been set aside for apartment and residential development exclusively for the employes of supply and equipment concerns that locate in supply row. Industral sites are accessible to two railroad right-of-ways.

The idea for supply row was conceived by the Texsteam Company, which was the first concern to locate in the new project. Houston Oil Field Material Company is presently constructing its new offices and warehouses in supply row and other supply companies are expected to locate there as building permits become available.

Restrictions in supply row include uniform modern architecture and construction, not only of the projected residential development, but of industrial buildings as well. Plans call for a central air conditioning and heating plant, and a recreation center with swimming pool and playgrounds. It is also planned to build a modern hotel and restaurant for the convenience of out-of-town buyers, engineers, and others who may desire accommodations in the east end industrial area. Harvin C. Moore is architect for the development.

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Emphasis on endurance has reduced to a minimum the rate of wear in working parts. It also has minimized the need of minor attention, not serious in itself, but which may involve a shut-down. If you have Case Oilfield engines, be sure they get the little care they require in order that they may give you the extra measure of endurance built into them. If you need more pumping power, ask your Case distributor about the possibility of supplying you. J. I. Case Co., Racine, Wis.

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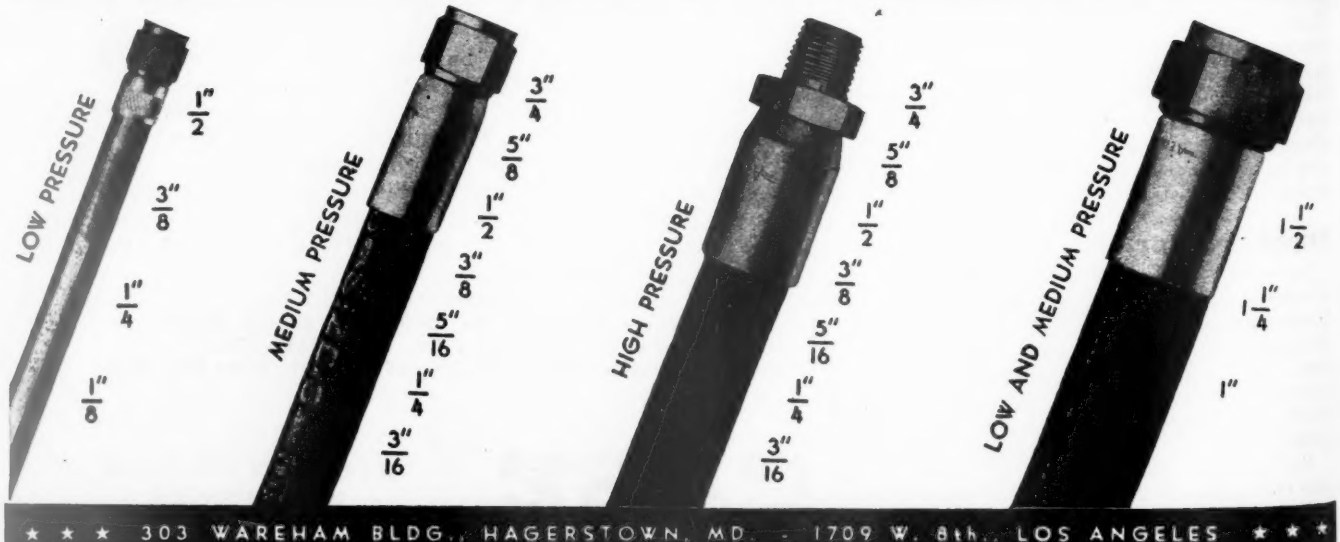

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(25) *Capacitors*

A new line of high-frequency paper-dielectric capacitors, available in ratings of 5000 to 20,000 volts d-c., 0.01 microfarad, has been announced by the General Electric Company. Developed primarily for grid and plate-blocking service in the electronic-oscillator circuits of high frequency induction heating equipments, they can also be used to advantage in other high frequency oscillator circuits of a similar nature.

The high voltage paper-dielectric capacitors are of relatively high capacitance for high frequency units, and yet they are more economical than the conventional high frequency units of considerably smaller capacitance values. They can, therefore, be applied with savings in cost as well as reduced losses and lower voltage drop across the capacitor.

The internal kraft paper and aluminum foil assemblies, compactly arranged and thoroughly impregnated with a low loss liquid dielectric, are hermetically sealed in rectangular metallic cases. The size of the case cover and the overall dimensions of the capacitor is reduced by use of a single insulated terminal, provided with a threaded terminal stud. For the other terminal, a stud is provided for connection to the case cover.

The units are supplied with removable footed type brackets, which provide for a firm four-point mounting in any position. The 20,000-volt rating is available in two designs—one in a plain case, and the other with cooling fins to permit a higher current-carrying capacity.

(26) *Portable drills*

A new development of Thor "armored in plastic" portable electric drills that introduces a side handle type machine has been announced by Independent Pneumatic Tool Company, Chicago, Illinois.

The new side handle type Thor drills are identical in construction to the original "armored in plastic" pistol grip machines, except for the side handle. The gear case, field case and handle are molded in the specially-developed "Thorite" plastic.

All internal operating parts are supported in a metal frame entirely separate of the plastic housings—an independent unit so constructed that the tool will operate perfectly with all housings detached.

The new Thor side handle drills are available in three speeds: 2500 r.p.m., 3750 r.p.m., and 5000 r.p.m.

(27) *Clamp fixture*

A new steel clamp fixture has been announced by the Cincinnati Tool Company, 4089 Montgomery Road, Cincinnati 12, Ohio.

The frame, slide, and screw of this clamp fixture are entirely of steel, making it an exceptionally rugged tool and insuring long life.

A feature strongly stressed by the manufacturer is the slide, made of heat-treated steel. Simple in design, this slide will not slip on pipe under pressure, yet it is easily released when pressure is removed, it is asserted. Clamping surface is 1½ in. by 1½ in.

(28) *Magnaflux inspection*

American Inspection Service, Dallas, Texas, announces the perfection of a completely equipped field inspection unit, mounted on a truck chassis, for the Magnaflux inspection of drill pipe, tool joints, drill collars, and other vital drilling equipment.

In the past the Magnaflux method of inspection has been limited to aircraft, locomotive, and other industrial plants where high voltage current was available.

This precision method of locating cracks and other discontinuities in steel parts has been adapted to the inspection of oil field equipment by the construction of a self-powered unit developed and built by the engineers of the American Inspection Service.

The Magnaflux method of testing metals for defects employs a high-amperage low voltage current, which is placed in the part to be inspected, in a controlled amount and in a controlled direction. Any discontinuity that transverses this field offers a reluctance to its passage and causes some of the field to push out into the external air, setting up local north and south poles along the edges of the discontinuity. When a specially prepared powder of finely divided paramagnetic particles is applied to the area of inspection, those particles coming into contact with this external field will be attracted to the two poles and will outline, by a powder build-up, the extent of the discontinuity or defect.

It is asserted that by the location and rejection or salvage of those drill pipe joints that contain minute fatigue cracks or other discontinuities, many twist-offs and consequent expensive fishing jobs may be averted.

This service is made available to the drilling industry at the well, on the pipe rack, or in the overhaul shop.

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(29) *New engine design cuts fuel consumption*

A new discovery in the diesel engine field, which will enable the engine operator to use either gas or oil as fuel without any electrical sparking device, and which will reduce fuel consumption of gas engines by 20 to 25 per cent, is revealed by Ralph L. Boyer, chief engineer, of The Cooper-Bessemer Corporation, Mount Vernon, Ohio, diesel manufacturers.

The new discovery is the result of experimentation that began in 1928, Boyer states. Recently efforts have been rewarded by the successful operation of a natural gas engine on the diesel principle. This enables the unit to operate on a wide variety of fuels including fuel oil, natural gas, manufactured and coke oven gases, sewage gas, and refinery by-products.

The conversion from liquid to gas fuel is as simple as the closing of one valve and the opening of another with the engine operating continuously at full load, Boyer says. Although conversion from one fuel to another has been possible in the past, it has always been necessary to shut down and exchange major or minor parts of the engine.

The new principle will enable the engine to have the same fuel economy regardless of the type of fuel used. It raises the normal 25 per cent thermo-efficiency of the gas engine to the 35 per cent thermo-efficiency common in diesel oil engines.

Several times since 1928, Boyer states, engineers in the diesel field thought they had the answer to the multi-fuel conversion problem but in the past it has been thought necessary to inject the gas under high pressure of from 1200 to 1500 lb. This involved complications that overcame the advantages obtained. The new Cooper-Bessemer development makes possible the use of gas at normal pressure and the change from one fuel to another without the necessity of a shutdown, it is asserted.

The significance of the new discovery is particularly impressive when a modern transcontinental pipe lines is considered. Many of these pipe lines have from 100,000 to 150,000 hp. of gas engines installed along their length that drive the compressors or pumps that deliver the fuel to the markets of the East. The total fuel used by these engines for 150,000 hp. would amount to 36,000,000 cu. ft. of gas per day, which is about one-third of a single day's total consumption of a city with a population of a million.

When operating as gas engines, these new gas diesels would save from 5,000,000 to 6,000,000 cu. ft. of gas for domestic and industrial consumption per day. If these engines are converted to oil fuel —and they could be in a moment's notice, to any or all oil fuels—the total fuel consumption of 36,000,000 cu. ft. of gas could be made available for consumer use.

If this new principle had been discovered some time prior to the present gas shortage, the curtailment of war production such as has been in existence in recent weeks might have been avoided, Boyer says.

The Cooper-Bessemer Corporation, one of the largest builders of diesel engines and gas compressors in the country, already has engines embodying the new principles in production along with its standard line of marine and stationary engines and standard compressor units.

(30) *Molding powder*

Molded synthetic rubber parts with excellent resistance to solvents, greases, oils, fuels, sunlight, ozone, and atmospheric oxidation are now possible through the use of a new molding powder developed by the Thiokol Corporation of Trenton, New Jersey. The new powder, which becomes vulcanized at 300°F. to 360°F. to form a tough resilient elastic solid, has proved itself an excellent material for compounds that are required to remain flexible at temperatures below minus 50°F. and remains serviceable to temperatures in excess of 220°F.

An excellent material for a wide range of industrial parts such as washers, valve seat disks, diaphragms, gaskets, grommets, etc., the new "Thiokol" molding powder can be compounded to obtain finished parts with a wide range of hardness, it is stated.

In considering the properties molded from this powder, they should be thought of in terms of soft vulcanized rubber rather than of hard rigid plastics. For example, rigid plastics display tensile strengths of from 1,000 to 10,000 lb. with elongations up to 1 per cent, whereas soft rubber goods fall into the tensile range of from 100 to 1000 per cent. The physical properties of the compounds shown are within the range normally considered satisfactory for most rubber mechanical goods applications.

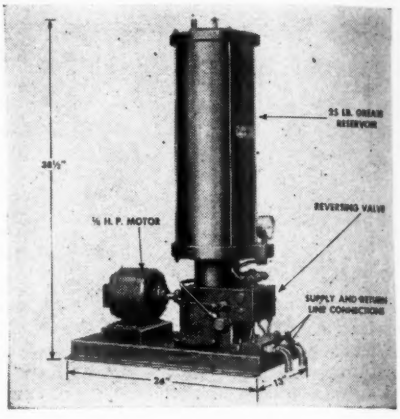
In general, the physical properties of parts molded from these powders can be arrived at from the table below, which summarizes properties obtained from 610 molding powder: *Properties of parts molded from "Thiokol" molding powder MP 610:*

Hardness (Shore Durometer)	60 ± 5
Tensile strength, lb. per sq. in.	1000
Elongation at break, per cent	400
Brittle point	—60°F.
Maximum service temp.	250°F.
Resistance to abrasion	Good
Resistance to sunlight	Excellent
Resistance to ultra violet light	Excellent
Resistance to ozone	Excellent
Volume swell in:	
Mineral oil	2.5%
Aromatic gasoline[1]	16.0
Gasoline	3.0
Kerosine	2.5
Turpentine	2.5
Linseed oil	1.0
Ethyl alcohol	5.0
Acetone	37.0
Carbon tetrachloride	48.0

[1]Aromatic gasoline consists of 60 per cent aviation gasoline, 20 per cent toluol, 15 per cent xylol, and 5 per cent benzol.

(31) *Lubrication system*

Recently announced by The Farval Corporation, Cleveland, Ohio, is the Automatic Central Pumping Unit DC-25. This is a small size, double plunger, slide valve type of pumping unit that provides a positive high pressure pump for the handling of all types of lubricants without the use of springs, check valves, or stuffing boxes. The complete system will handle either oil or grease and requires no attention except the renewal of the lubricant supply in the reservoir.



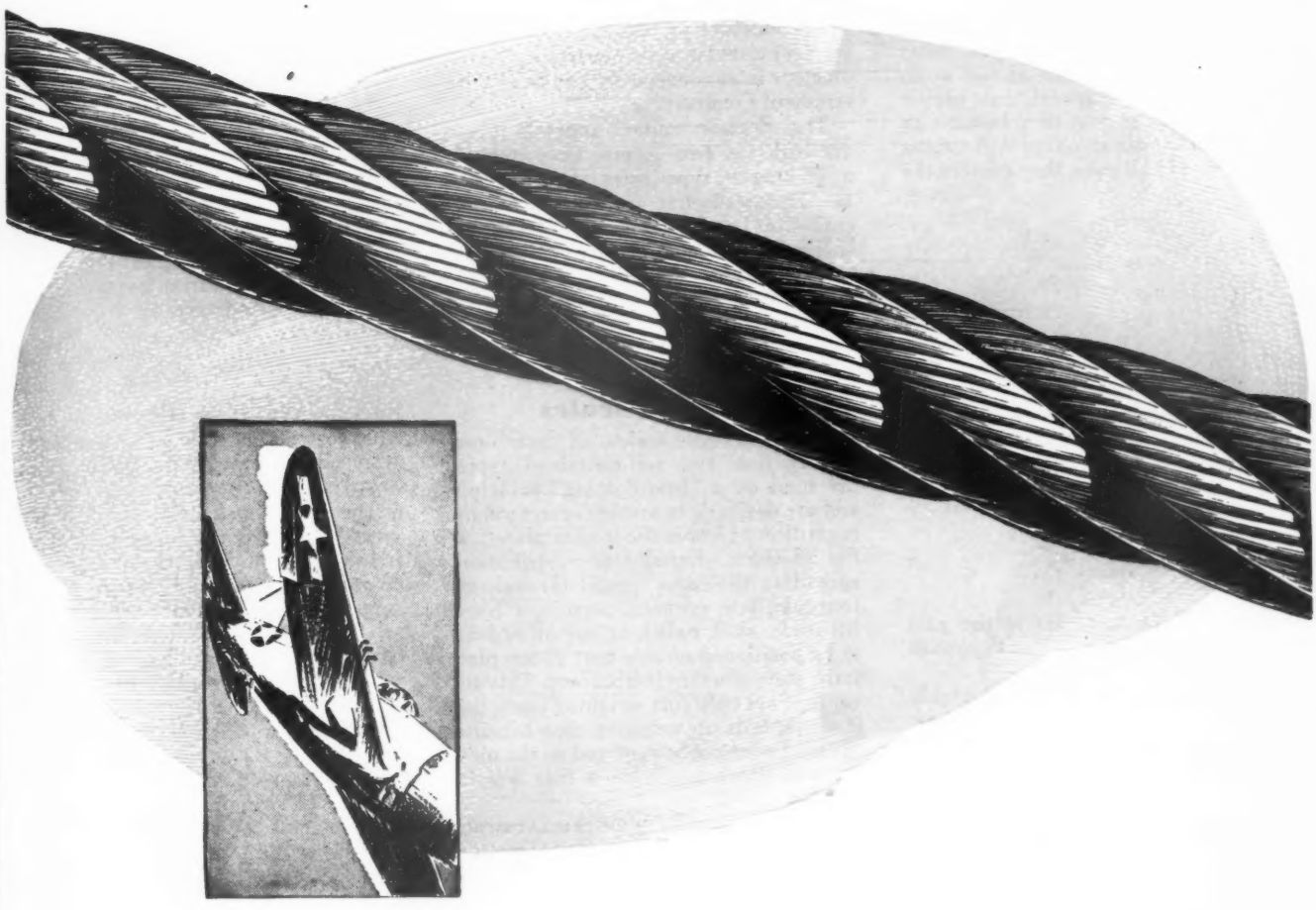
Similar to the larger Farval heavy duty units, the DC-25 central pumping unit delivers lubricant under pressure to all bearings in the system through two main supply lines serving a Farval Dauline measuring valve at each bearing. Frequency of operation is controlled by an electric time clock. A suitable signal device is available to indicate any interruption to the normal operation of the system. For individual machine lubrication, this central pumping unit can also be supplied with rotary drive and with hydraulic timing. With this arrangement, the unit will start and stop with the equipment served.

(32) *Clevis ring*

A new clevis ring has been introduced by Poulsen and Nardon, Inc., Los Angeles manufacturer of stamped parts and fittings. The ring can be produced in a simple stamping operation. It is made to exacting dimensions from alloy steel, carefully formed to retain the full strength qualities of the steel. Each ring is cadmium plated, and conforms to specification ANQQ-P-421.

Tests have shown that the strength factor of this clevis ring is in excess of the cable with which it is used, according to the manufacturer. It fits any standard cable terminal.

BUY WAR BONDS



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(33) *Tubing protectors*

Patterson-Ballagh tubing protectors are now back in full production after two years "layoff" because of war work. These oil-proof, wear-resistant plastic rings are so made that they become an integral part of the standard API tubing collar. Made in all sizes, they prevent the

metal-to-metal contact that in the past caused so many expensive "wet" jobs in pumping wells.

These protectors have proved highly satisfactory on many types of applications and especially in service in pumping wells below 4000 ft. where tubing collars are worn because of the pulsation of the tubing caused by the pump action, according to the manufacturer. In one North Louisiana field more than 5000 of these tubing protectors have been installed. Some have been in service for more than 5 years. From 8 to 100 are used on each well. Wells so crooked that pumping cost was more than the gross revenue, are now able to produce economically, it is asserted. In wells where collars were worn within two weeks, these protectors have been in service for years without serious wear.

(34) *1H Positioner*

Sturdy and compact, the bench model 1H hand-operated positioner provides a handy tool to facilitate production and repair welding, assembly, overhauling, grinding, drilling, hard-surfacing, and similar operations on all small work. Its ability to handle small units efficiently makes the Model 1H a versatile machine for welding, assembly, maintenance, and repair shops. The capacity of this Ransome bench model positioner has a tilting range of 150 deg., revolves 360 deg., and can be locked in position at any degree of tilt. The 16-in. table top is equipped with 9/16-in. slots. Swivel base is available if desired.

The Ransome Machinery Company now manufactures welding and work positioners from 100-lb. capacity hand-operated to 40,000-lb. motor-operated, also turning rolls and other special positioning equipment.

The manufacturer is the Ransome Machinery Company, subsidiary of Worthington Pump and Machinery Corporation, 1433 South Second Street, Dunellen, New Jersey.

(35) *Electric controls*

Introduction of electric contact controls for circular chart electronic potentiometers is announced by the Brown Instrument Company.

The electric contact controllers are available in two forms. One contains a locking-in type relay designed primarily for electric furnace control. It can also be used for applications involving use of contactors and for processes requiring a differential gap.

The second type, without a relay, is designed for direct control of motorized valves, operation of signalling devices, and for applications requiring a "dead" neutral.

The electric contact control mechanism, according to engineers of the Brown company, Philadelphia precision industrial instrument division of Minneapolis-Honeywell Regulator Company, will be available for circular potentiometer pneumatic controllers. It will serve, when applied to these instruments, as an auxiliary switch for operation of signal lamps and other devices.

(36) *Platform scales*

Kron platform scales, of both open construction and self-contained types, are built on a "free floating" principle and are designed to assure correct weight regardless of where the load is placed on the platform. Equal load distribution, spreading the same weight through all four platform corners, permits a hand lift truck, skid, pallet, or any other load to be positioned on any part of the platform at no sacrifice in accuracy. This advantage not only cuts weighing costs, but it also speeds up weighing time because the load need not be centered on the platform in order to obtain a true weight reading.

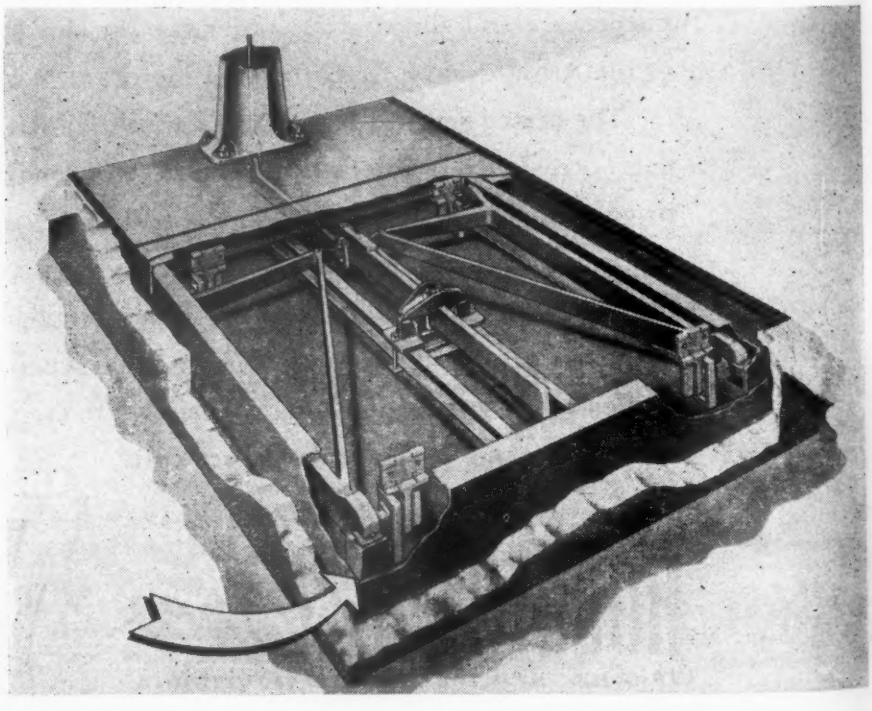
This "free floating" platform construction prevents lateral platform motion from being transmitted to the platform lever system. It absorbs all swinging motion and results in pivot and bearing wear only when a load is actually weighed. In addition, this construction eliminates binding and friction, thus lengthening pivot and bearing life and lowering maintenance and replacement costs.

The self-contained dormant platform is extremely shallow and will fit into floors of wood, metal, composition or concrete requiring a minimum of depth. This is made possible by the method of suspension with the main platform levers being in the same plane.

The open construction dormant platform is built on a structural steel "H" frame on which the entire lever system is mounted, keeping all corner fulcrum supports in permanent alignment. Both self-contained and open construction types of Kron dormant platform scales can be shifted from place to place without damage or loss of accuracy.

All upper and lower platform frames are constructed entirely of structural steel plate and shapes permitting great strength in a minimum of space. Lever, fulcrum, and leg castings are normalized and well seasoned before being machined, free of stress and distortion. Pivots and bearings are made of special analysis steel alloys, ground to exacting limits. All pivots, bearings, and loops are given a plated coating to prevent corrosion.

Kron scales are available for weighing, counting, batching, testing, measuring. The manufacturer is The Yale and Towne Manufacturing Company, Philadelphia Division, Philadelphia 24, Pennsylvania.



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Today we are establishing records in manufacturing and prompt delivery of vital products for our Armed Services all over the world.
Today we are planning for tomorrow—planning to carry on in peacetime production the same high degree of engineering skill—manufacturing accuracy—assembly-line speed—infallible inspection that have been the natural developments of our concept of an adaptable contract manufacturer.
Before the war many manufacturers discovered that Oiljak could build certain parts of their products better and more economically than they could in their own plants. Many articles in common use, and bearing famous trademarks, contained important parts designed, machined and made by Oiljak.
Economy in production will be an important factor in peacetime manufacturing. Perhaps a discussion with our engineers of any particularly difficult or expensive operation may result in our being able to serve you as we have others. We invite your inquiries.
MACHINING • STAMPING • WELDING • PLATING • FINISHING • ASSEMBLING
The Oiljak Manufacturing Co., Inc.
MONTCLAIR, N. J.
METAL MANUFACTURERS
THE JOB COMPLETE . . . from blueprint to finished product
BUY MORE BONDS

First Choice

OF OUR NATION'S GREAT INDUSTRIES

Great industries, following in the footsteps of hundreds of towns and cities, give first choice to Layne installed Wells and Layne built Vertical Turbine Pumps. Industrial engineers have found that there is no "just as good." They have found that Layne's reputation for quality and efficiency equipment is absolutely unmatched. If you should wonder why, check just a few of the major reasons:

Layne is the Nation's oldest and most successful pioneer in designing and building Vertical Turbine Pumps. They developed and hold exclusive patents on many tremendously important efficiency features.

Next, Layne perfected a type of Well installation that produces more water, saves costly horsepower and invariably lasts longer.

Every Layne Pump is precision-built in Layne's own Engineer supervised factory. All materials: iron, steel, bronze, brass, nickel, etc., are of a uniformly extra high quality.

To avoid excessive repair expense, high operation cost, shorter life and possible failure at a critical time, place your confidence in, and demand, Layne Wells and Vertical Turbine Pumps. For late literature, address, Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

LAYNE PUMPS — *fulfill every need for producing large quantities of water at low cost from wells, streams, mines or reservoirs. Send for literature.*

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City, Mo. ★ Layne-Western Co. of Minnesota, Minneapolis, Minn. ★ International Water Supply Ltd., London, Ontario, Canada

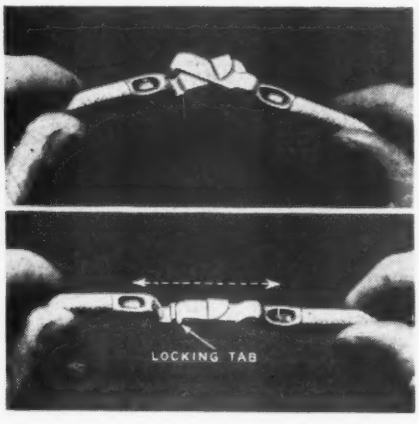
LAYNE

WELL WATER SYSTEMS
VERTICAL TURBINE PUMPS

(37) *Electrical connector*

A new self-locking quick-disconnect type of electrical connector, known as the Burndy Clasp, designed especially for small wires and approved by the U. S. Army Air Forces, is now available from Burndy Engineering Company, Inc., New York, New York.

Composed of two identical halves, this new quick-disconnect slides together in jackknife fashion and locks in a positive position with a slight pull. This exclusive locking feature prevents loosening or pulling apart in service, even though someone should inadvertently pull or jerk on the cables.



To lock the Burndy quick-disconnect clasp, the two halves are crossed, swung into line and pulled slightly to the locked position. No further pulling or thrust in any direction will disconnect. The connection is quickly and easily opened, however, by simply pushing the halves together and giving them a slight swing.

Ample pressure between the two halves creates good electrical contact. Made of copper and heavily silver plated, the Burndy Clasp has high electrical efficiency and excellent resistance to corrosion.

In addition to the self-locking feature, this connector utilizes the Burndy Hydent principle for gripping the cable ends. By indenting the clasp socket to the cable strands, a permanently tight and shock-proof connection is obtained. The same Burndy Hytool, used for other types of Burndy Hydent connectors, is used for indenting the clasp.

Four clasp connector sizes accommodate 10 sizes of aircraft cable—from No. 18 to No. 8. The two smaller sizes include an insulation grip on the cable sockets, whereas the two larger sizes are supplied without insulation grips.

Although the clasp was engineered by Burndy to meet wartime aircraft requirements, its convenience and self-locking feature suggest many applications in other fields. It is believed that a simple connector such as this should be of interest wherever a positive connection of the quick-disconnect type is desirable.

(39) *Carcomatic clutch*

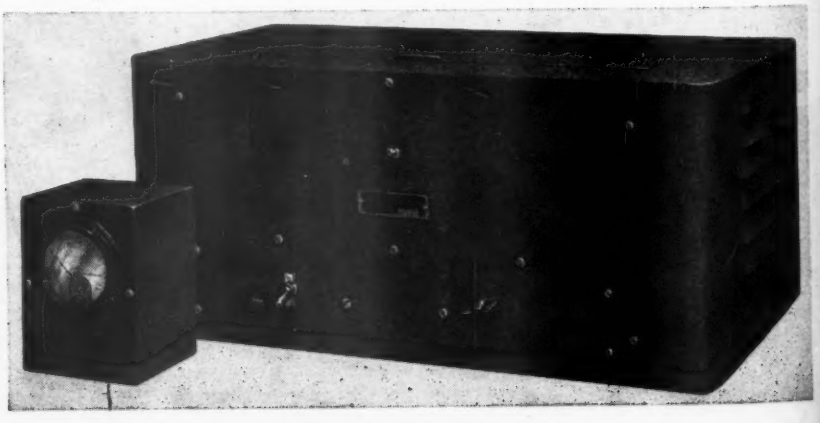
One of the first of the postwar products of Pacific Car and Foundry Company to be placed on the market is the Carcomatic air-operated clutch. These clutches are offered in a wide range of capacities and sizes.

Subjected to extensive field tests covering more than 3 years of use by industrial operators, these clutches have proved the value of their design, freedom from maintenance and economy of operation under the most adverse conditions, according to the manufacturer.

(38) *Detonation meter for gasoline evaluation*

Working in conjunction with laboratories of Phillips Petroleum, Engineering Laboratories, Inc., of Tulsa, Oklahoma, have developed a detonation meter for use with the F-4 Engine Method of gasoline evaluation. The instrument is small and compact, is portable, and requires no alteration to the engine for installation. It has been approved by the Committee on Fuel Research and has recently been demonstrated at forums held in various parts of the country.

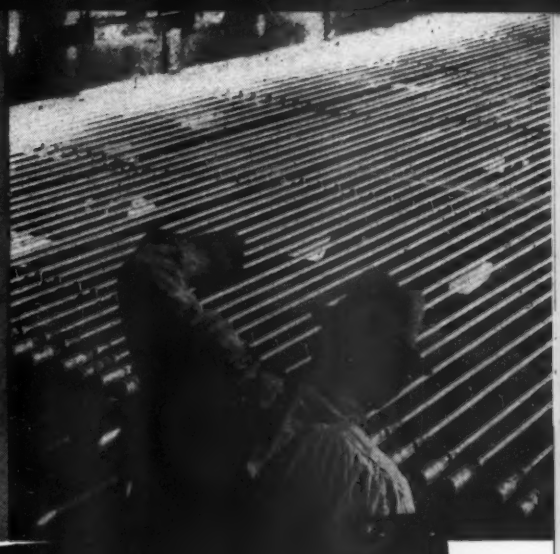
The instrument is installed with a Lane-Wells D-7/8 internal pick-up and has a high degree of accuracy for visually indicating the detonation point of aviation fuels, the manufacturer asserts.



ELI detonation indicator

Far-Reaching Research—From raw materials to the well, experimentation and studies are constantly conducted to determine how "Oilwell" Rods can be improved. Here is fatigue-testing of sucker-rod steel under Hydrogen-sulphide well conditions.

Precision Manufacture—These controlled fine-grain carbon and alloy steels are formed, heat-treated and machined by skilled "Oilwell" workmen using modern precision equipment. Heat-treatment starts in this huge pyrometer-controlled normalizing furnace where "Oilwell" Sucker Rods are normalized over their entire length in one heat.



...ge Inspection—"Oilwell" Rods are carefully ...pected throughout every phase of manufac... from raw materials to the finished product. ...e are a few of the more than 100 gages used ... assure uniform accuracy of A.P.I. threaded ...

...ected Field Stocks—Most field stocks are ...ntained in sucker-rod warehouses which ...e centrally located to assure convenient short ...ts direct to your leases. These warehouses ...e specially designed for the storing of rods ...sers where they are fully protected from ... weather. Modern rod-handling facilities ...minate danger of nicking or otherwise dam...ng rods in loading or unloading.

...ld Engineering Service—"Oilwell" sales and ...ervice engineers have helped many opera... analyze well conditions and find the solu... to difficult pumping problems. If you ever ...ed this engineering assistance, you know it a ...mptly, helpful and efficient service.

Five Factors

SUCKER-ROD performance is affected by so many factors that excellence in one or two phases of manufacture does not necessarily assure satisfactory operation. In supplying sucker rods to the oil industry sincere effort is made to control every phase of both manufacture and distribution—so that you can always depend upon maximum service from "Oilwell."

Look at the illustrations on this page. These are a few of the important steps taken by "Oilwell" to assure best possible performance. If you need normalized carbon steel rods for ordinary service or fully heat-treated alloy steel rods for severe conditions, come to "Oilwell."

OIL WELL SUPPLY COMPANY

Executive Office — Dallas, Texas
Division Offices—Columbus, Ohio
Dallas, Texas Los Angeles, Calif.

Export Division Office—
30 Rockefeller Plaza
New York City

Branches Serving All Oil Fields

UNITED STATES STEEL

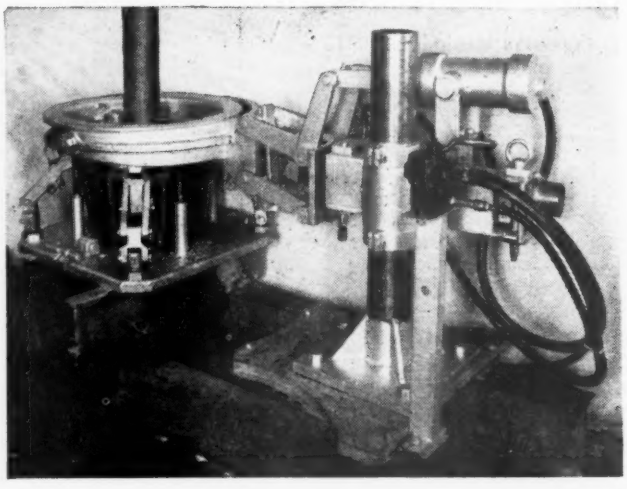
USS

"OILWELL"

(40) *Rotary slips*

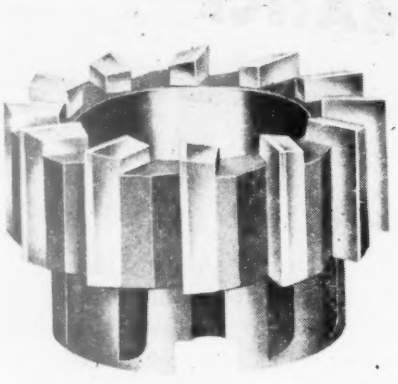
Ben F. Kelley Company, Tulsa, Oklahoma, announces the introduction of what is termed an unusual piece of equipment—their Kelco safety air-operated rotary pipe slip. The new air-operated unit prevents slips from dropping in the hole, short kinks under tool joints, and other damage to equipment, it is asserted. Safety to workmen, said Ben F. Kelley, inventor of the device, is its chief advantage.

The new Kelco safety slips are sturdily and compactly built and easily transported, installed, and operated. The Ben F. Kelley Company is the manufacturer of the Kelco safety spinning line cathead now available in 4 different models, designed to meet safety hazards and operating conditions.



(41) *Shell end mills*

Small standard shell end mills with brazed-in blades made of Haynes Stellite cobalt - chromium - tungsten alloy are available from Haynes Stellite Company, Kokomo, Indiana, unit of Union Carbide and Carbon Corporation. These cutters



are supplied with blades of either Haynes Stellite 98M2 or Star J-Metal brazed into a steel body. Diameters range from 1¼ to 6 in., with face thicknesses from 1 to 2¼ in. These cutters are supplied ready for use. They are used for milling aluminum, bronze, cast iron, brass, alloys, and some steels.

(42) *Lonn blow guns*

As air and water hose in industrial plants and other places are very often used with spray guns, nozzles, and hand-operated valves, The B. F. Goodrich Company is adding to its line of industrial hose a complete series of Lonn blow guns, fingertip-control of which is made possible by the use of rubber.

This announcement by E. F. Tomlinson, general manager of B. F. Goodrich Industrial Products Sales Division, reveals that the company will handle exclusively, through distributor channels, nation-wide sales of these valves made by the Lonn Manufacturing Company, Indianapolis, Indiana.

Lonn blow guns are known as air savers and water savers because of their ability to exercise a positive control over air or water flow, thus reduce consumption of water and compressed air.

Air savers, water savers, and spray guns are offered in several styles with various degrees of flow or restricted flow.

The Lonn valve features an internal trigger principle and involves only 3 simple working parts. It is opened and closed without the use of springs, levers, or pushbuttons, merely by flexing the rubber nozzle or hose.

Lonn valves have a close relationship to the B. F. Goodrich industrial rubber line because the company manufactures all types of rubber hose, many of which are used in conjunction with air, water, and fluid spray guns. The rubber of all Lonn valves is made by B. F. Goodrich.

(43) *Control instruments*

The Bristol Company, Waterbury 91, Connecticut, announces the development of a new series of indicating air-operated control instruments. The new instruments, known as the Model 93 series, are built for controlling temperature, pressure, vacuum, liquid level, and humidity.

Model 93 controllers operate on the free-vane principle of automatic control. They have a throttling range of from ½ to 15 per cent with the adjusting mechanism arranged so that changes in the throttling range can be made by the user without the need of tools.

Model 93 controllers are direct-set instruments that can be set to control at any value within the range of the instrument by turning the control pointer to the desired value. They are built so that they can be changed by a finger adjustment from reverse to direct action or vice versa.

(44) *6MH live center*

A "live" lathe center for handling heavy loads up to almost 6 tons is announced by the Ideal Commutator Dresser Company, 1526 Park Avenue, Sycamore, Illinois.

This new center, called the No. 6MH, has a guaranteed tolerance of 0.0000 to 0.0005. To handle radial loads up to 5750 lb. and thrust loads up to 8500 lb., a special bearing arrangement is used. Two precision ball bearings in tandem support the spindle at the front, and two angular contact ball bearings preloaded support it at the rear of the housing. This arrangement also eliminates radial play and possible chatter. For positive protection of these bearings against the entrance of chips, dust, coolant, and other foreign matter, two sealing rings are used.

A unique feature of design is the ease in redressing the point. The center is simply inserted in the lathe tailstock with the retainer plug removed. Then a small steel rod is screwed into the threaded hole in the end of the spindle of the live center. By rotating the spindle point with this rod and by using a tool post grinder, accurate redressing of the points can be made quickly and efficiently.

This center is made with the No. 6 Morse taper only. Shipping weight is approximately 20 lb. It supplements the regular line of Ideal live centers with Morse tapers from No. 1 to No. 5.

(45) *Electrode holder*

A new holder for welding electrodes, said to be light in weight (22 oz.) and low in cost ($2.50), has been announced

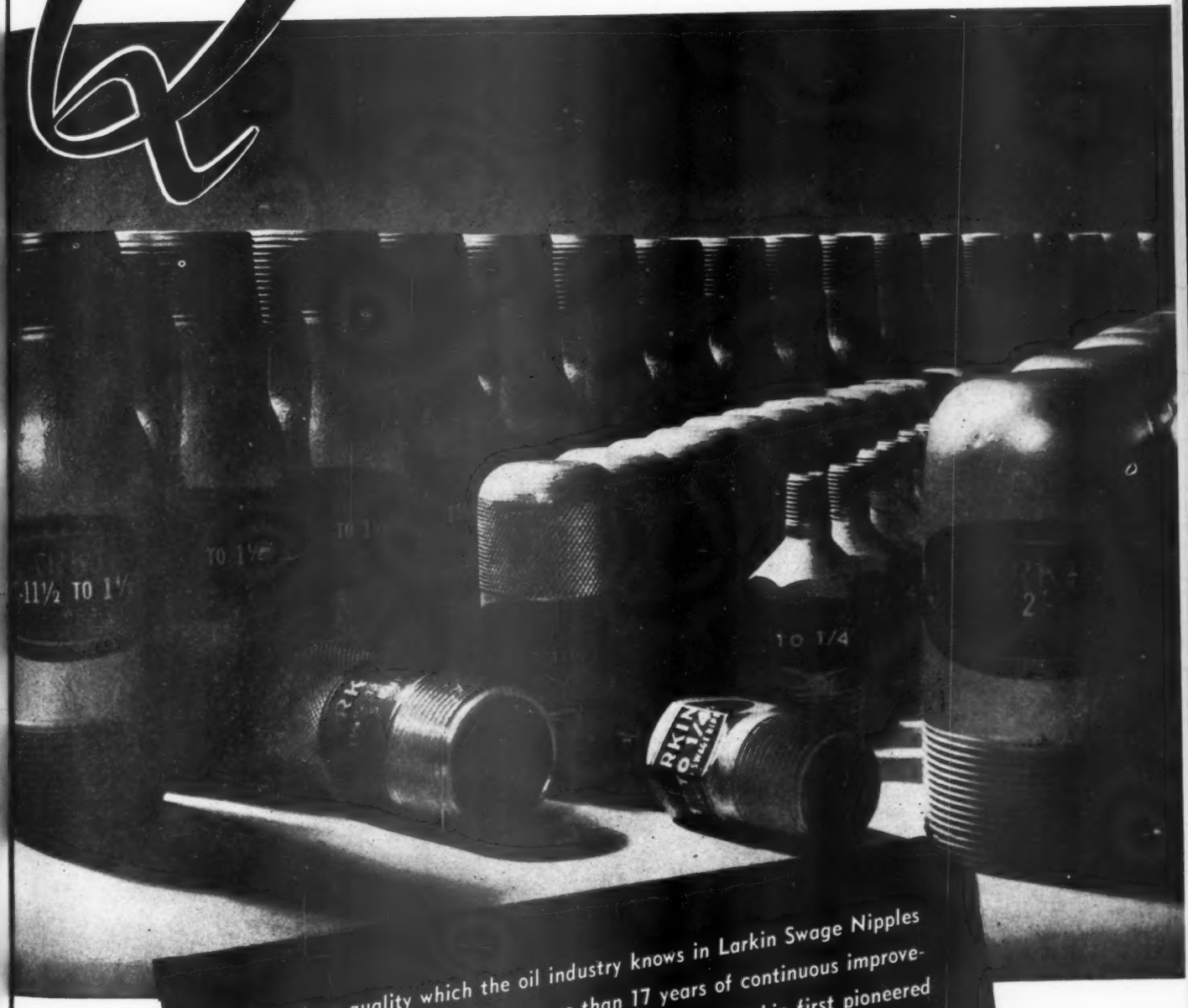
by The Lincoln Electric Company, Cleveland, Ohio.

Having a current rating of 300 amp. with ample capacity for overload, the new holder will handle various sizes of electrodes ranging from 1/16-in. diam. to ¼-in. diam., inclusive.

Jaws, made of high-conducting and wear-resisting copper alloy known as "Lincalloy," will withstand rough treatment and are fully guarded from contacting the work by a durable spring steel insulating guard that is easily replaceable. The trigger of the holder is of molded, heat-resisting inorganic material.

Other features of this new type "INS" electrode holder include: Hollow, air-cooled, heat-resisting fiber handle, excellent balance and equally good performance on both a-c. and d-c. current. The holder is designed to hold the electrode securely at any angle yet permit quick and easy change of rods.

Quality



The unique quality which the oil industry knows in Larkin Swage Nipples and Bull Plugs is the result of more than 17 years of continuous improvements in design, materials and workmanship. Since Larkin first pioneered a standardization on lengths for all sizes of these products our striving toward perfection has never ceased.

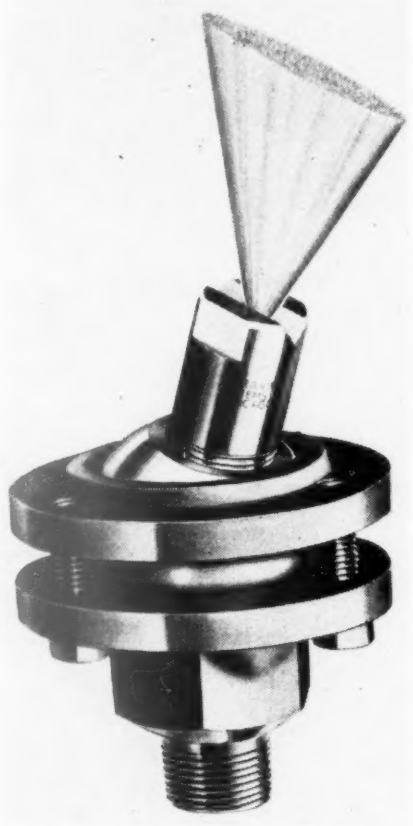
LARKIN PACKER COMPANY, INC.

ST. LOUIS, MO.

WAREHOUSES: Houston, Corpus Christi, Odessa, Shreveport, Tulsa, Great Bend, Salem. EXPORT: 74 Trinity Place, New York City

(46) *Adjustable joint*

The new Spraying Systems adjustable joint, because of new ball and socket design, provides a full 50 deg. nozzle adjustment range in any plane at right angle to the face of the joint. The thick socket plates permit an unusually strong friction grip, more than sufficient to hold the nozzle in fixed position, no matter how extreme the spraying operation. Three machine screws are quickly turned to adjust the joint as required.



Illustrated is the adjustable joint with a "Veejet" flat spray nozzle mounted in the socket. This adjustable joint is made in brass or steel as standard, but may be had in a variety of special steel alloys as required. Various sizes of joints with standard pipe thread can be supplied, such as ⅛ in., ¼ in., ⅜ in., ½ in., ¾ in., and 1 in. Adjustable joints of this type have already been tested and proved. Typical applications are found in equipment for washing, rinsing, and paint flow-coating.

Spraying Systems Company, 4020 West Lake Street, Chicago 24, Illinois, are the manufacturers.

(47) *Synthetic latex*

A new synthetic rubber latex has been developed and is in production by United States Rubber Company at the government's synthetic latex plant at Naugatuck, Connecticut, according to J. P. Coe, general manager of the company's Naugatuck chemical and synthetic rubber divisions.

"The new latex is a modification of the butadiene-styrene type of synthetic rubber," Coe stated. "Advantages of the new latex are greater uniformity and more easy handling and shipping. It mixes well with other ingredients and is therefore very easily compounded for uniform viscosity and other desired properties."

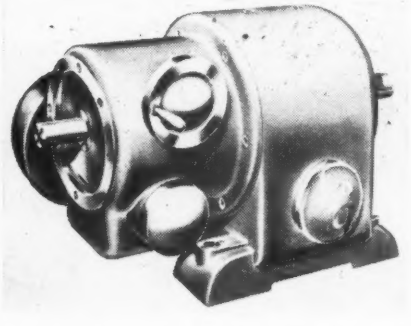
"The new latex gives more uniform tensile strength and improvement in other physical properties in most finished products, but much work remains to be done before it is the equal of natural rubber latex in thin wall dipped goods." Coe said.

"This development is just one more example of the continuous improvement in synthetic rubber technology that has been accomplished by scientists of the rubber, petroleum, and chemical industries cooperating under supervision of Rubber Reserve Company in a united war effort. More than 100,000 lb., dry weight, of this latex was produced in its first 60 days of manufacture."

(48) *Variable speed drive*

The new Lombard variable speed drive is filling a long-felt need in the processing industries with the transmission of power at different speed levels, according to the manufacturer, Lombard Governor Corporation, Ashland, Massachusetts. Particularly adaptable because of its compact size and streamlined design to virtually every type of variable speed transmission work, this drive is finding ready acceptance in the modernization of present equipment as well as in use on new equipment.

Pumps, blowers, heavy stock conveyors and machinery power in the processing field are already using this type of power transmission equipment. The accompanying illustration shows the modern streamline design. The importance and convenience of an individually-controlled drive for each machine is readily understood. Danger of tie-up due to the slipping of belts from the overhead drive is eliminated, as well as a general stoppage of all machines from a temporary failure of the central power system.



It is compact, being scarcely larger than the motor with which it is used—even in the higher horsepowers, 15, 25, 50, 100 hp. or higher. The complete unit with the motor has the size and appearance of two standard a-c. motors coupled together. Weighing not much more than the motor that drives it, the Lombard variable speed drive assures ease of handling and installation. Long life is assured as the gears are totally enclosed and run in oil. This factor also reduces noise, makes for safety and eliminates the possibility of dirt, grit, and moisture getting into the gears, at the same time virtually eliminating maintenance cost, it is stated.

The Lombard variable speed drive uses the V-belt as a control medium only, rather than for both drive and control, primary speed reduction being accomplished by conventional gearing methods. Through this new gearing arrangement 90 per cent of the power goes through conventional gears where only 10 per cent passes through the V-belt, a minimum load that avoids slippage. The lower gear ratio also affords finer hair-line control, insuring peak production speeds. Low maintenance is made possible as the easy accessible V-belt is the only part likely to need replacement over a long period of time. The efficiency at low speeds is equal to, if not higher than, the efficiencies usually attained. Having the variable speed output shaft furnished concentric with the motor shaft gives it a direct line drive. Remote control is also available, with horizontally split casings optional.

(49) *Boring bar*

Just announced by the Robert H. Clark Company of Beverly Hills, California, is the Clark precision lever-lock boring bar. According to the manufacturer, these new boring bars provide many unusual features and answer a long-felt need for a bar with separate tool bits for small diameter holes.

Presented as a companion tool to the Clark adjustable tool holder, these new boring bars are available in sets of four: 3/16 in. by 5 in., ¼ in. by 6 in., ⅜ in. by 7 in., and ½ in. by 8 in.

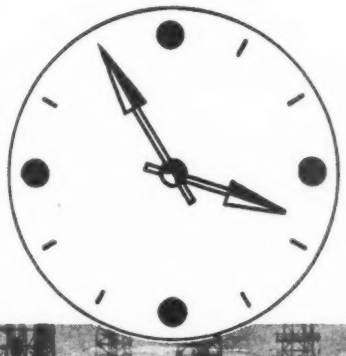
Boring bars with separate cuttters in sizes below ⅜ in. have never before been generally available, yet these Clark lever-lock boring bars are designed for use without bushings or adaptors. They require no special clamps or holders. The parallel type Clark adjustable tool holders hold them securely, and together they make a practical combination, it is stated.

Leading manufacturers of tungsten carbide tool bits now supply solid round carbide bits in small sizes down to 3/32 in. diameter for use in the Clark lever-lock boring bar. The evenly distributed pressure of the lever-lock clamp prevents the breakage that so frequently occurs when pressure is applied only at one point by means of a set-screw.

Made from selected tool steel and heat treated for maximum rigidity the modern design and sturdy construction of these tools assure accuracy in precision internal boring and threading, the manufacturer states. The exclusive lever-lock feature securely grips the tool bit in such a way that boring or threading to the bottom of a hole is possible without interference from set-screws or bolts.

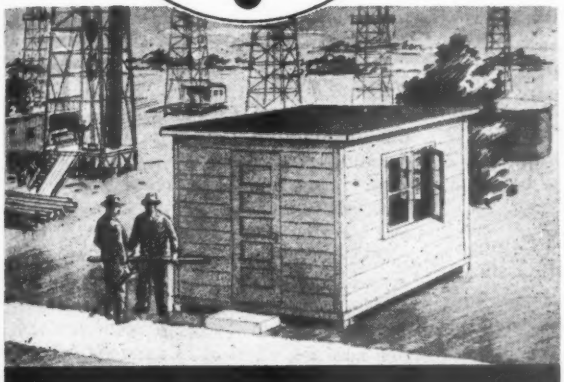
One precision ground high speed threading bit and one boring bit are provided.

Housing IN A MATTER OF Hours - NOT MONTHS!



Right now, wouldn't that solve many of your critical problems . . . vital employee housing . . . precious equipment shelter?

Investigate TEXAS PRE-FAB's remarkable oil-industry offering. Call in a TEXAS PRE-FAB field engineer as your housing consultant. Learn how automobile line-production methods, now applied to housing, provide new building economy. Three types of TEXAS PRE-FABs follow:



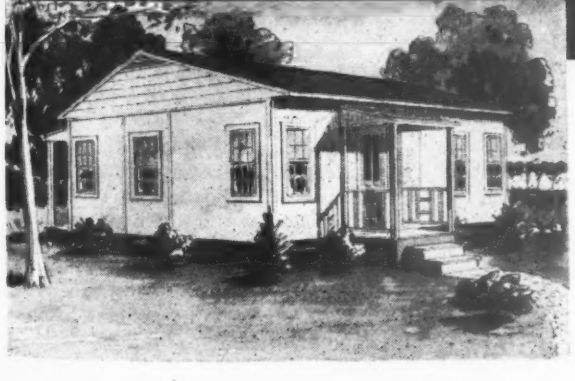
UTILITY BUILDINGS, 8' x 10'—ideal for tool sheds, equipment shelters, storage quarters, etc. Comes in 7 sections that two men can erect in a couple of hours. Just as easily demounted and moved to another locality. Has 1 door and 1 or more casement glass windows.

TEXAS PRE-FAB

HOMETTES—Quick, comfortable residences for exploration, drilling and pipeline crews. Portability permits moving the house to follow the job. Also 16′ x 16′ TEXAS PRE-FAB Commercial Units of same basic design (in singles or multiples up to 96′ long) provide bunk houses . . . commissary quarters . . . community wash room and lavatory facilities . . . material storage rooms.

TEXAS PRE-FAB

COTTAGE HOMES—Permanent, comfortable, low-cost dwellings erected in a fraction of the time required for conventional construction. A big step toward greater employee satisfaction and its resulting increase in employee productivity.



For detailed information, mail coupon below.
Or 'phone us if we can be of immediate service.

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LIMIT PLUGS

The superiority of Robinson products is reflected in our LIMIT PLUG—built with ample water courses to withstand high pressures—and constructed to accommodate large expansions . . . plus these features:

- Cypress wood construction
- Cast-iron guide weight
- Uniform pressure packs and solidifies sidewall.

ROBINSON PACKER CO.

P. O. Box 1408
TULSA, OKLAHOMA
Factory: Coffeyville, Kansas

(50) *Aluminum mallets*

Empire mallets and Basa replaceable face hammers are now available with aluminum heads and faces. These new aluminum mallets and hammer faces have been developed to provide a single mallet or hammer for every kind of work where a soft faced striking tool is required.

Besides being sparkproof and easily machined for refacing, aluminum is not brittle and does not chip. When worn, heads or faces of aluminum are readily cut, turned or ground for longer use. In addition, the exclusive split jaw design of the Basa hammer head further assists quick replacement of faces.

Present users of Basa hammers will also be interested to learn that the new aluminum faces are interchangeable with the plastic, rawhide, copper, and babbitt faces with which these hammers have been supplied previously.

The aluminum used in Empire mallets and Basa hammers is a special alloy, developed specifically for the purpose. The proportions of both the mallet heads and hammer faces have been carefully worked out to provide well balanced tools that are easy to handle.

The manufacturer is Greene, Tweed and Company, New York, New York.

(51) *Dehumidifier*

A new dehumidifier known as "Water-Sorber," is announced by the General Air Conditioning Company of Oakley, Cincinnati, Ohio. According to the manufacturer, Water-Sorber embodies many exclusive features of design and operation that enable it to draw much more moisture from the air, per pound of chemical, than devices previously marketed for this service. These features are:

Terraced construction. Three receptacles specially arranged one below the other catch the residue liquid in descending stages, and permit this liquid, which also contains active chemical, to continue to absorb additional moisture. This exclusive terraced construction is said to add approximately 70 per cent to the absorption ability of the chemical.

Chemical cubes used in place of conventional types of absorbent. By presenting more exposed surfaces and consequently a greater total absorption area to the moist air, these cubes remove more moisture.

"Flue-action." Air passes over the chemical cubes. It enters at the bottom of the cube container through perforations. This provides slower, more uniform, and thorough melting of cubes—still further increasing moisture absorption.

Water-Sorber is made in a convenient, practical size. A single unit will service from 800 to 1000 cu. ft. For a larger area, two, three, or more Water-Sorbers are used as required.

This new dehumidifier, for which patent is pending, is designed for both home and industrial use. It efficiently dries the air in warehouses, tool rooms, stock rooms, vaults, clothes closets, pantries, basements, and other confined spaces. Thus it prevents harmful dampness, mold, and mildew.

Shipping weight is 15 lb. which includes 10 lb. of cubes. Extra supplies of cubes are available in 10-lb. cans.

(52) *Reaming shells*

Reaming shells for use with diamond core bits are now being carried in stock available for immediate shipment in 3 standard types and four sizes by the mining division of the Carboloy Company, Inc., Detroit 32, Michigan, producer of cemented carbides, carbide tipped cutting tools, and core bits. These reaming shells are provided with a series of "Sinta-Set" diamond impregnated carbide inserts designed to increase core bit life.

The inserts—brazed into recesses around the periphery of the reaming shells—maintain gage during the entire useful life of the bit. Therefore, when the original bit is replaced, no further reaming in the drilled hole is required. Each insert is impregnated throughout one-half of its thickness with a quantity of highly selected West African bort.

Three or four inserts are mounted around each shell, according to the size of the reamer. As repeated use wears the inserts and thus reduces them in size, the reaming shell can easily be brought back to its proper diameter by heating the inserts with a torch until the braze metal has melted, removing the inserts, placing a shim of the proper thickness in the recess, and then re-brazing the inserts on top of the shims. Thus greater life can be obtained from the reaming shell because it can be used until the shell itself is worn so thin that it must be discarded. No dressing of the diamonds is required, for the wearing action of drilling keeps fresh cutting faces of the bort constantly exposed.

Both single and double tube shells are available. Three of the most commonly used types of reaming shells: Longyear, Sullivan, and Sprague and Henwood, are carried in stock, equipped with the "Sinta-Set" inserts. These standard shells will fit standard core drill fittings as listed in United States Department of Commerce Bulletin CS-17-32.

The four sizes offered from stock are:

EX, carrying 3 inserts.
AX, carrying 4 inserts.
BX, carrying 4 inserts.
NX, carrying 4 inserts.

Special types and sizes of reaming shells can be equipped with diamond impregnated carbide inserts, at a slight increase in cost over standard shells. For such special requirements, the user sends his own special reaming shells to Carboloy Company and has the finished product made up to suit his own specifications. "Sinta-Set" inserts may also be obtained unattached to shells, if desired.

BUY WAR BONDS

OTIS PRESSURE CONTROL SERVICE - EQUIPMENT

Sub-Surface Facts

ON THE CONTROL OF FLOWING WELLS

No. 19 | 1945 | DALLAS, TEXAS

STOP SURFACE FREEZING WITH AN OTIS REMOVABLE BOTTOM HOLE REGULATOR

NATURAL FORMATION HEAT ABSORBS ALL LOSSES OF TEMPERATURE DUE TO GAS EXPANSION

TUBING STRING ACTS AS "MILE LONG" HEATER

The Otis Removable Bottom Hole Regulator is essentially a bottom hole choke, the capacity of which can be regulated simply by adjusting the surface choke. This makes possible variable rates of flow through the tubing with the principal pressure drop being taken across the Bottom Hole Regulator. The use of this tool provides surface-controlled rate of production with all the advantages of bottom hole choking. The opening through the Regulator automatically adjusts itself when the size of the surface choke is changed.

The extent to which the regulator valve opens depends upon the size of the surface choke used; the larger the surface choke the greater will be the opening in the Regulator, while the smaller the surface choke the smaller will be the opening through the Regulator. The operation of the Regulator is entirely automatic and variable rates of flow at substantially constant delivery pressures can be maintained by merely adjusting the surface choke. The daily delivery can be varied through a range of from zero to 9,000,000 cu. ft.; the maximum rate, however, being dependent upon the ability of the well to produce at the reduced flowing pressure.

Tubing flowing pressures are always reduced to a safe workable limit. Freezing at any rate of production is positively eliminated.

During the relatively short time since the first Bottom Hole Regulator was installed, over 1,000 successful installations have been made. A majority of these have been in the deep pressure wells in the Gulf Coast area where pressures exceed 4,000 p. s. i.; however, the tool is just as extensively used in relatively lower pressure wells where freezing conditions are encountered.

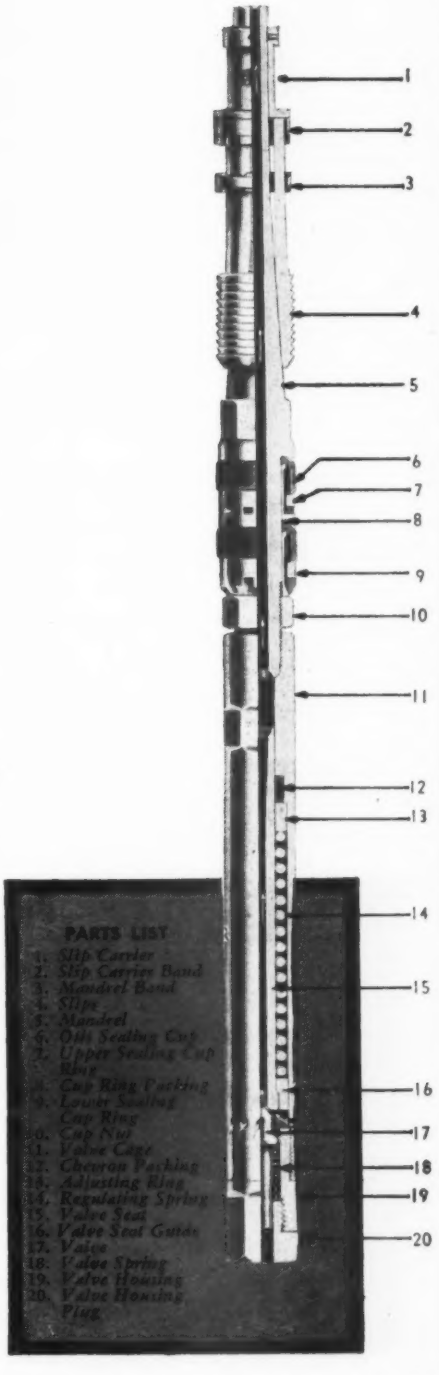
PURPOSE AND GENERAL USE

The purpose for which the Bottom Hole Regulator is most generally used is to prevent freezing of surface flow lines and connections. This is accomplished by setting the Regulator at a depth where the temperature of the flow stream is sufficiently high to allow for the loss in temperature caused by the pressure drop across the Regulator without approaching freezing temperature. The tubing string above the Regulator acts as a "mile long heater" to reheat the gas before it reaches the surface controls. The Regulator, therefore, utilizes sub-surface earth temperatures to accomplish the same purpose as the surface heaters. This method of preventing frozen flow lines is most desirable because it requires no constant supervision and eliminates the necessity of a fire as used by surface heater. Any surface flowing pressure can be reduced to a safe non-freezing level simply by the installation of one or more Regulators.

Data and formulas are now available to determine the maximum safe pressure drop that can be taken at any depth without freezing.

RUN AND PULLED ON ORDINARY STEEL MEASURING LINE

The Otis Bottom Hole Regulator is run or pulled under pressure on an ordinary steel measuring line without disturbing the tubing or well pressure. Otis service crews, trained and skilled in the installation of all Otis subsurface tools, are available in most high pressure areas.



A REQUEST

Due to the increased demand for our wire line service together with the shortage of equipment and experienced help, our service units are now operating in excess of 100 hours per week.

To give these men much needed rest, we ask that you refrain from requesting service on Sunday unless urgently needed. Our field men will greatly appreciate your cooperation in this matter.

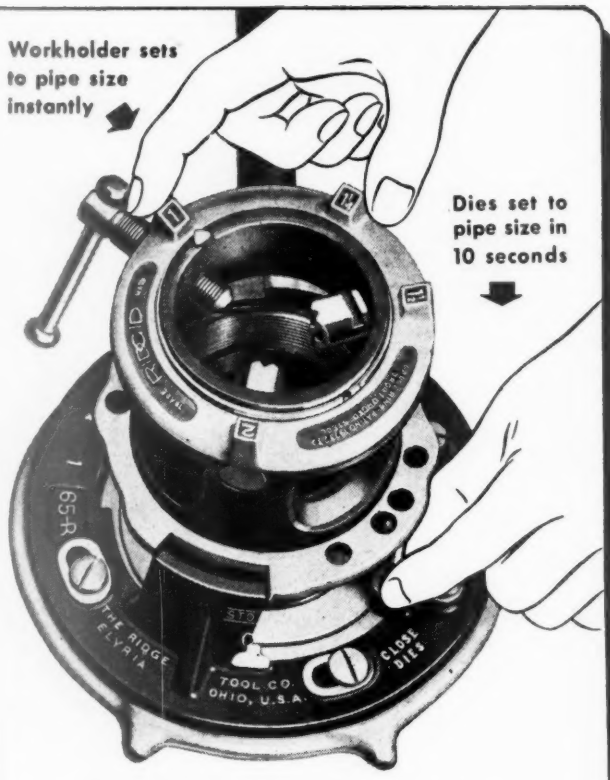
OTIS PRESSURE CONTROL, INC.

DALLAS, TEXAS

Branches: Houston, Corpus Christi and Wichita Falls, Texas; Hobbs, N. M.; New Iberia, La.; Magnolia, Ark.; Oklahoma City, Okla.

Representatives: Otis Eastern Service, Inc., Wellsville, N. Y.; Western Pressure Control, Los Angeles and Bakersfield, Calif.

Export Office: 74 Trinity Place, New York City

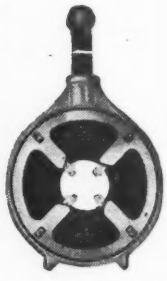

Workholder sets to pipe size instantly
Dies set to pipe size in 10 seconds
65-R
THE RIDGE TOOL CO. ELYRIA, OHIO, U.S.A.
CLOSE DIES

PERFECT THREADS

with surprising ease and speed

with this self-contained RIDGID No. 65R

● No wonder the popularity of this threader has spread widely. The speed and ease with which it cuts clean perfect threads on 1" to 2" pipe are reasons enough. One set of high speed steel chasers threads all 4 sizes—and they set to pipe size in 10 seconds! Workholder sets instantly! You'll like other work-saver features of this rugged steel-and-malleable die stock—it pays you to try the self-contained No. 65R at your Supply House.



No. 65R stands up handily when you want it to.

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY · ELYRIA, OHIO, U. S. A.

TRADE LITERATURE

Publications listed are sent free upon request.

(53) *Worthington equipment*

The Worthington Pump and Machinery Corporation, Harrison, New Jersey, has issued a number of bulletins explaining new company equipment. Bulletin No. C-1100-B17, "Coolers for Mechanical Refrigeration," tells of coolers using ammonia, freon, methyl chloride, propane, butane, and other refrigerants. No. 1-685-B1 is a 22-page 2-color bulletin giving the characteristics of LFC angle four cycle gas engine compressors. "Absorption Refrigerating Machines," No. C-1100-B8, gives general information on refrigerating machines manufactured by the company together with diagrams of the various types. A folder tells of horizontal simplex direct-acting piston pumps. Two sheets, 30 and 31, tell of Worthington diesel engines in operation in Columbus, Wisconsin, and Waverly, Iowa.

(54) *Alco products*

Bulletins No. 1034 and 5001, released by American Locomotive Company, New York, New York, describe various company products. Both are in color and are well-illustrated. Bulletin 1034 describes the triple service products of American Locomotive Company's products division, and bulletin 5001 tells of various types of springs designed and manufactured by the company's railway steel-spring division.

(55) *Electrical equipment*

"High-Voltage D-C. Supply," a pamphlet published by General Electric Company, Schenectady, New York, explains the company's new metal-enclosed equipment. This equipment provides a convenient and reliable source of high-voltage d-c. power for applications such as testing of electric equipment, precipitation, induction heating, radio, and miscellaneous industrial and electronic applications requiring high-voltage d-c.

(56) *Air uses*

Ingersoll-Rand Company, New York, New York, announces the publication of a new 24-page 2-color booklet entitled "A Little Air Power Will Do Many a Big Job." Containing information useful to every shop man it is a clearing house to enable production men to benefit from one another's ideas and to show what is being done with small compressors or with a small amount of air from a shop air line.

(57) *Specialized tools*

Houston Oil Field Material Company, Inc., has published a catalog of cutting and fishing, sidewall coring, directional drilling and other specialized tools manufactured and used by the Homco cutting and fishing tool department. This is illustrated in three colors, contains a pictorial index of the tools, presents a brief informative article on cutting and fishing, and describes the operation of the tools.

(58) *Cooling towers*

A cooling tower bulletin, published by The Fluor Corporation, Ltd., Los Angeles, California, contains data for calculating cooling tower sizes, essential points in cooling tower selection and details of construction, and operation of Fluor aerator cooling towers. It is a 20-page illustrated booklet with photographs of typical installations, section drawings, and performance charts.

(59) *Hole enlarger*

Grant Oil Tool Company, Los Angeles, California, has literature available on the "rat hole" enlarger, a new tool developed to improve the methods of opening and enlarging holes. The roller bearing construction provides long life and a high degree of operating efficiency, company officials state.

(60) *Welding hints*

Booklet ADI-889, "Airco Tensile and Guided Bend Test Machine," published by Air Reduction Sales Company, New York, New York, explains the company's new welding machine. Compact, portable, sturdy and accurate, it provides a means of qualifying welding operators without the delay of tests, company officials say.

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 92

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue, and 89-91, inclusive, in the January, 1945, issue.

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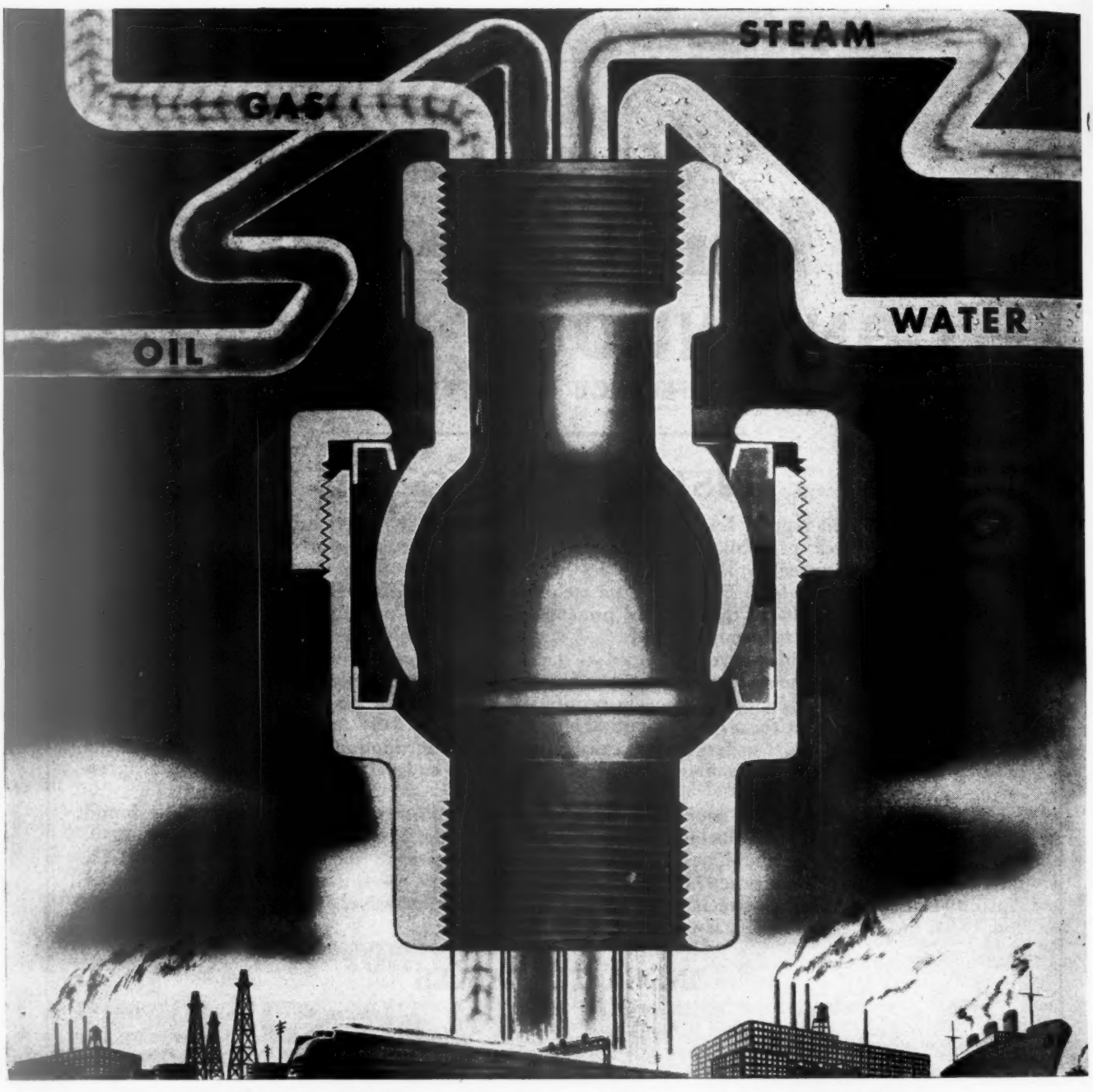
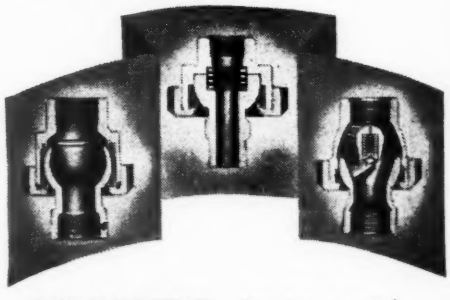


BARCO KEEPS VITAL FLUIDS FLOWING

The destructive action of vibration and shock can't hurt fluid-conveying pipes protected by Barco Flexible Joints. By means of responsive movement, Barco compensates for every contraction and expansion—preventing leaks and breaks. Its range of designs covers every flexible joint problem in transportation and industry. Today, as in the past 30 years, Barco's experience and progressive skill stand ready to assist you. Barco Manufacturing Co., Not Inc., 1827 Winnemac Avenue, Chicago 40, Illinois.

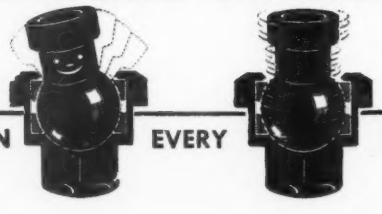
In Canada: The Holden Co., Ltd., Montreal, Canada



BARCO FLEXIBLE JOINTS

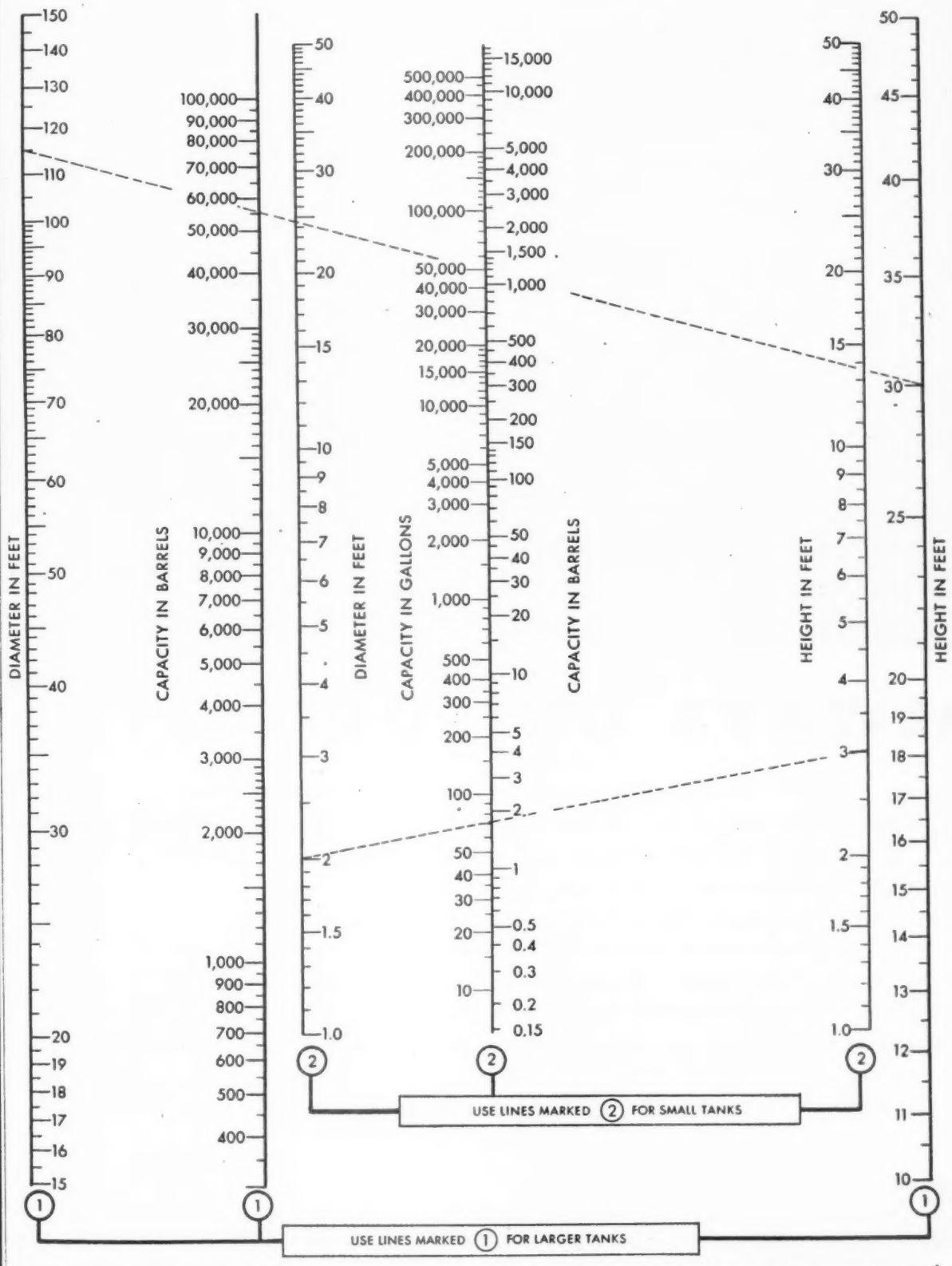
THE FREE ENTERPRISE SYSTEM IS THE SALVATION OF AMERICAN BUSINESS

Not just a swivel joint...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.



"MOVE IN EVERY DIRECTION"

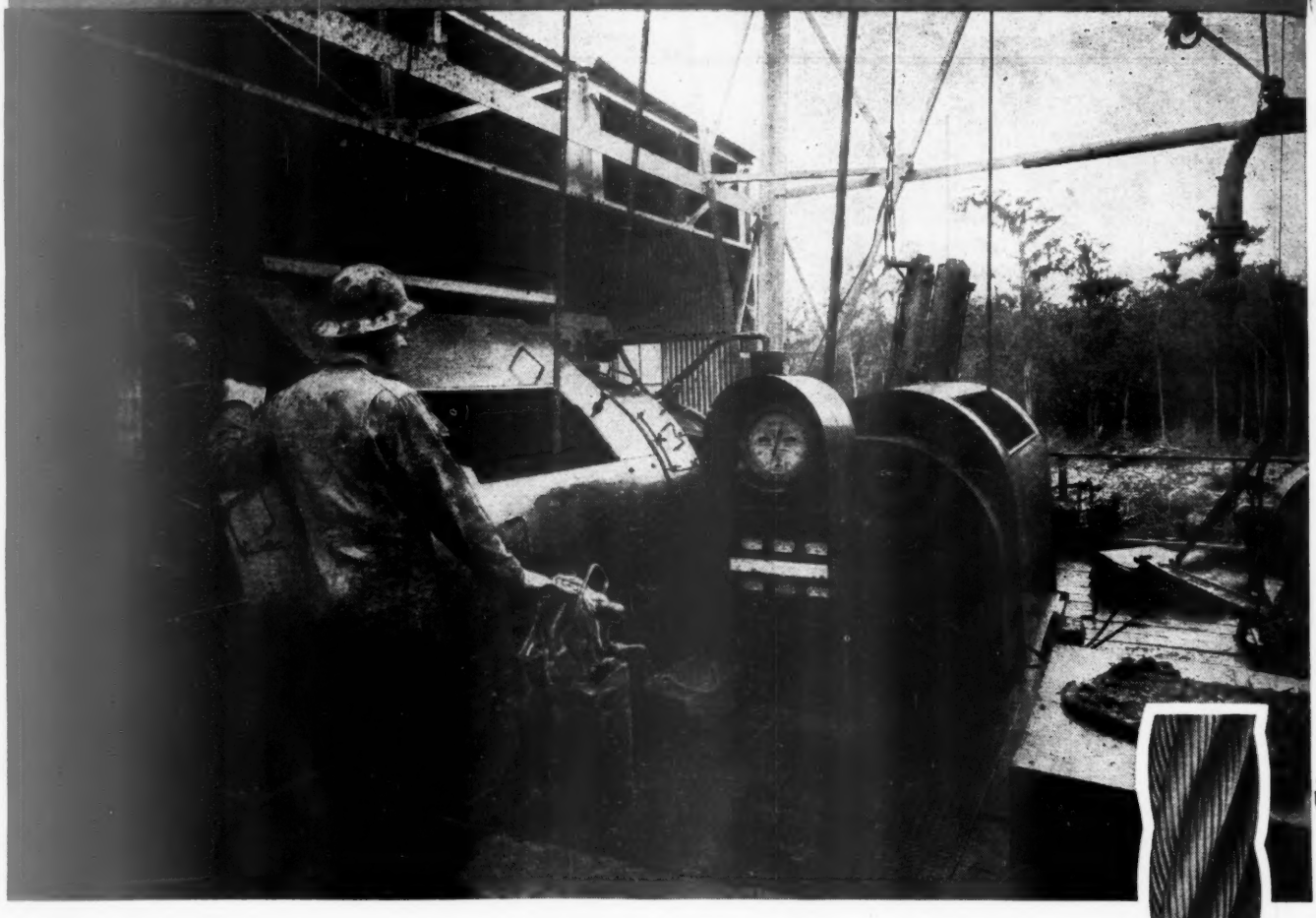
TANK CAPACITY CHART



Note: For approximate calculations.

—Chart courtesy Graver Tank and Manufacturing Co., Inc.

HAZARD LAY-SET *Preformed* ROTARY LINES



ALWAYS UNIFORM...

● It is the uniformity in quality of **HAZARD LAY-SET PREFORMED ROTARY LINES** that drillers everywhere most appreciate. Reel after reel, **LAY-SET** is uniform; always the same dependable line. Drillers know this to be true. That's why they prefer it.

Being preformed, Hazard **LAY-SET** is a limber, tractable line. It is easy to install; resists kinking and whipping; spools evenly. If you want a line that doesn't throw itself all over the derrick floor—that doesn't wave to the driller on the next lease—that doesn't pile up on the drum when you are sending up the empty traveling block *fast*—specify Hazard **LAY-SET** Preformed.

Distributors in all important oil field centers

ACCO

Wilkes-Barre, Pa., Chicago, Pittsburgh, Fort Worth, Houston, Wichita, San Francisco, Denver, Los Angeles

HAZARD WIRE ROPE DIVISION
AMERICAN CHAIN & CABLE • BRIDGEPORT

TRADE MARK

In Business for Your Safety

ESTIMATION OF VISCOSITY INDEX

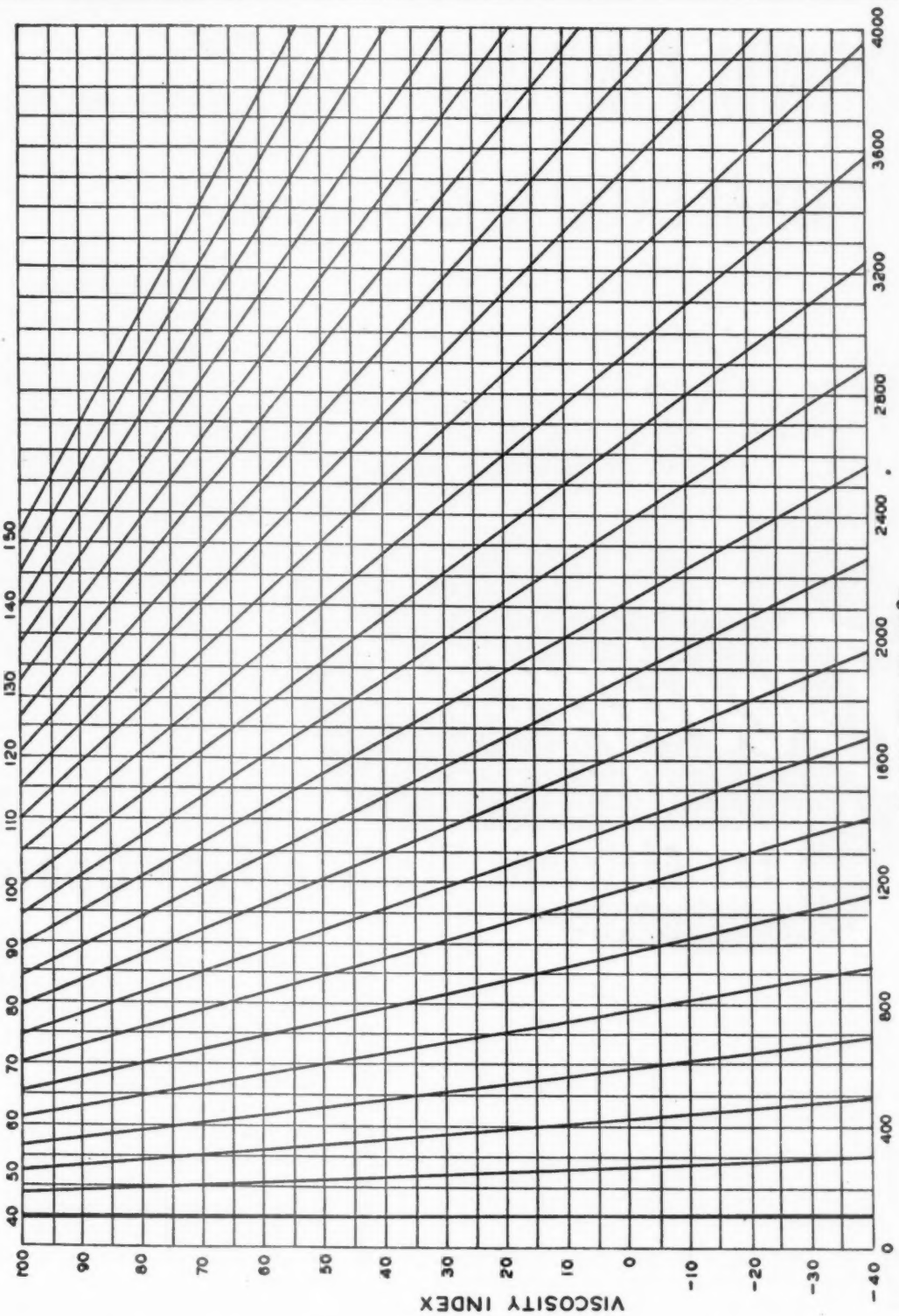
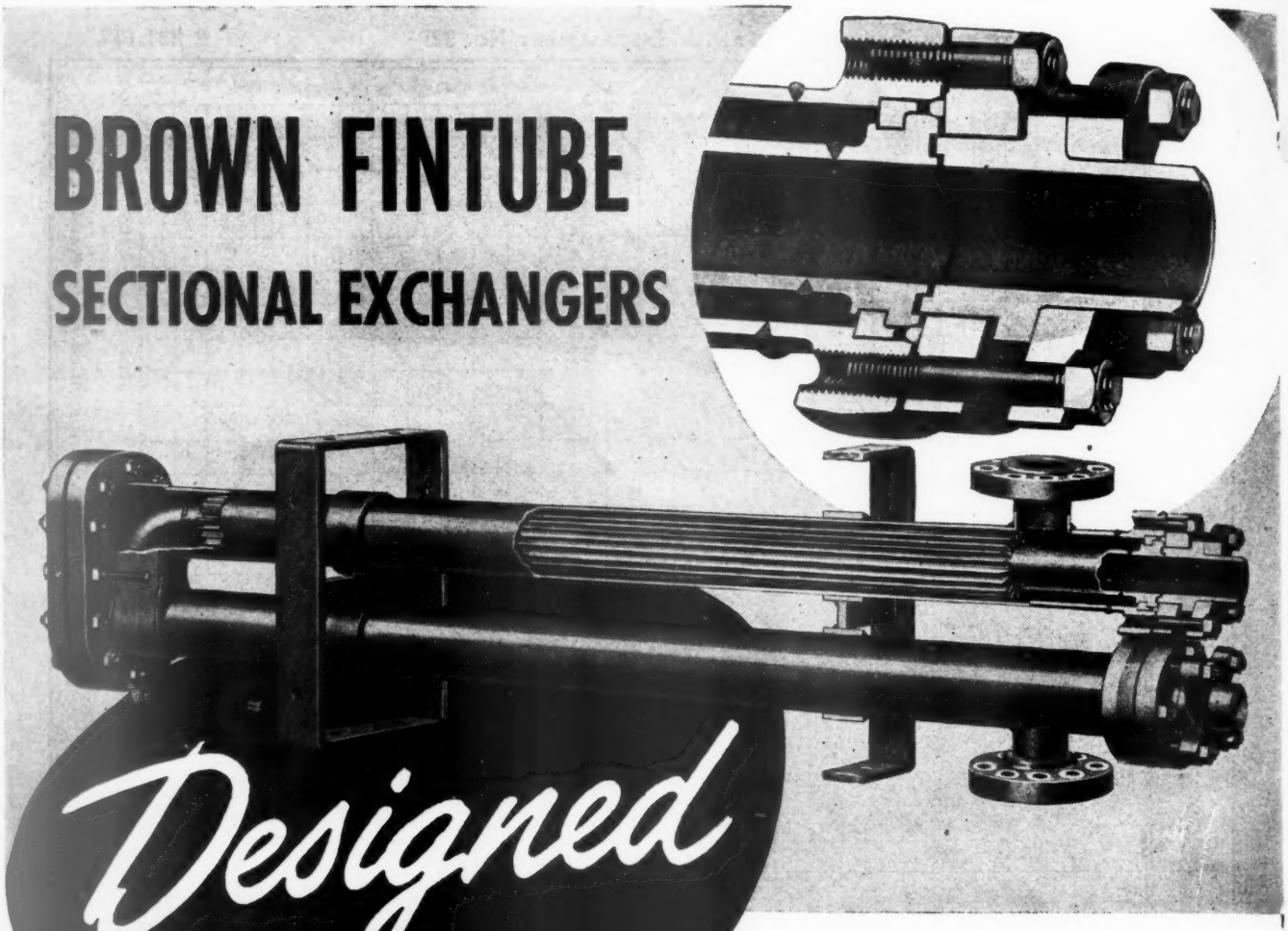


Chart by courtesy of Universal Oil Products Company.

Viscosity Index is a numerical value arbitrarily developed for lubricating oils to show the comparative change of viscosity with temperature. It is independent of viscosity, but varies with the nature of the constituent hydrocarbons. Lubricating oil fractions from a single crude oil source have approximately the same viscosity indices.

In estimating the viscosity index with the use of the chart, locate the viscosity of the oil at 100°F. on the abscissa at the bottom of the chart and follow upward on a vertical line to the point where the line crosses the oblique line extending from the viscosity of the oil at 210°F. shown on the abscissa on the top of the chart. At this intersection read horizontally the viscosity index on the ordinate at the left side of the chart. For oblique lines not shown, intermediate lines must be extrapolated.

BROWN FINTUBE
SECTIONAL EXCHANGERS



Designed
for Efficient Trouble-Free Operation

Service-proved, and ideally suited for a wide variety of duty and capacity requirements, Brown Fintube Sectional Heat Exchangers offer users many exclusive features that insure a maximum of long, efficient, satisfactory performance,— including:

1. Flanged construction throughout,— eliminating screw fittings and screw unions,— and avoiding torsional strains on any member.
2. Steel sealing rings that provide the tight closures needed for high temperatures and high pressures.
3. Gasketed seals, eliminating ground joints, and all maintenance troubles common to ground joint construction.
4. Gaskets are renewable, fully retained, and joints may be inspected easily before sealing.
5. Seals may be made or broken with a small standard wrench,— from the front — permitting close, side by side installation in minimum space.
6. This new flanged construction permits interior of fintube to be inspected and cleaned without disturbing shell side seal.
7. Sturdy rugged design, employing forged steel flanges with stud bolting. All joints have been tested to several times normal operating pressures.

Investigate Brown Fintube Exchangers for every capacity and duty requirement. Prices, recommendations, and fully descriptive literature sent promptly.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

POSITIVE METER FACTORS—PHYSICAL TEST CAR

Vacuum, in.	Factor	Vacuum, in.	Factor	Vacuum, in.	Factor	Vacuum, in.	Factor	Vacuum, in.	Factor
0.0	1.017	6.0	1.279	12.0	1.721	18.0	2.632	24.0	5.589
0.1	1.021	6.1	1.284	12.1	1.731	18.1	2.655	24.1	5.696
0.2	1.024	6.2	1.290	12.2	1.741	18.2	2.680	24.2	5.806
0.3	1.028	6.3	1.295	12.3	1.752	18.3	2.704	24.3	5.922
0.4	1.031	6.4	1.301	12.4	1.762	18.4	2.728	24.4	6.044
0.5	1.035	6.5	1.307	12.5	1.772	18.5	2.754	24.5	6.168
0.6	1.039	6.6	1.313	12.6	1.783	18.6	2.779	24.6	6.298
0.7	1.042	6.7	1.318	12.7	1.794	18.7	2.805	24.7	6.434
0.8	1.046	6.8	1.324	12.8	1.805	18.8	2.832	24.8	6.575
0.9	1.049	6.9	1.330	12.9	1.815	18.9	2.850	24.9	6.723
1.0	1.053	7.0	1.336	13.0	1.827	19.0	2.887	25.0	6.878
1.1	1.057	7.1	1.342	13.1	1.838	19.1	2.915	25.1	7.040
1.2	1.061	7.2	1.348	13.2	1.849	19.2	2.944	25.2	7.210
1.3	1.065	7.3	1.354	13.3	1.861	19.3	2.973	25.3	7.388
1.4	1.068	7.4	1.360	13.4	1.873	19.4	3.003	25.4	7.575
1.5	1.072	7.5	1.367	13.5	1.884	19.5	3.034	25.5	7.772
1.6	1.076	7.6	1.373	13.6	1.896	19.6	3.065	25.6	7.979
1.7	1.080	7.7	1.379	13.7	1.908	19.7	3.096	25.7	8.203
1.8	1.084	7.8	1.386	13.8	1.921	19.8	3.129	25.8	8.434
1.9	1.088	7.9	1.392	13.9	1.933	19.9	3.162	25.9	8.769
2.0	1.092	8.0	1.399	14.0	1.946	20.0	3.196	26.0	8.938
2.1	1.096	8.1	1.405	14.1	1.958	20.1	3.230	26.1	9.214
2.2	1.100	8.2	1.412	14.2	1.971	20.2	3.266	26.2	9.507
2.3	1.104	8.3	1.419	14.3	1.984	20.3	3.302	26.3	9.819
2.4	1.108	8.4	1.425	14.4	1.998	20.4	3.339	26.4	10.152
2.5	1.112	8.5	1.432	14.5	2.011	20.5	3.376	26.5	10.509
2.6	1.117	8.6	1.439	14.6	2.028	20.6	3.415	26.6	10.892
2.7	1.121	8.7	1.446	14.7	2.039	20.7	3.455	26.7	11.304
2.8	1.125	8.8	1.453	14.8	2.053	20.8	3.496	26.8	11.748
2.9	1.129	8.9	1.460	14.9	2.067	20.9	3.537	26.9	12.239
3.0	1.133	9.0	1.467	15.0	2.081	21.0	3.579	27.0	12.761
3.1	1.139	9.1	1.475	15.1	2.096	21.1	3.623	27.1	13.330
3.2	1.142	9.2	1.482	15.2	2.111	21.2	3.667	27.2	13.952
3.3	1.146	9.3	1.489	15.3	2.126	21.3	3.712	27.3	14.635
3.4	1.151	9.4	1.497	15.4	2.141	21.4	3.759	27.4	15.389
3.5	1.155	9.5	1.504	15.5	2.157	21.5	3.807	27.5	16.224
3.6	1.160	9.6	1.512	15.6	2.172	21.6	3.856	27.6	17.154
3.7	1.164	9.7	1.520	15.7	2.188	21.7	3.907	27.7	18.199
3.8	1.169	9.8	1.528	15.8	2.205	21.8	3.958	27.8	19.378
3.9	1.173	9.9	1.535	15.9	2.221	21.9	4.012	27.9	20.721
4.0	1.178	10.0	1.543	16.0	2.238	22.0	4.067	28.0	22.264
4.1	1.182	10.1	1.551	16.1	2.254	22.1	4.123	28.1	24.056
4.2	1.187	10.2	1.559	16.2	2.272	22.2	4.181	28.2	26.161
4.3	1.192	10.3	1.568	16.3	2.289	22.3	4.240	28.3	28.725
4.4	1.197	10.4	1.576	16.4	2.307	22.4	4.301	28.4	31.779
4.5	1.202	10.5	1.584	16.5	2.325	22.5	4.364	28.5	35.558
4.6	1.206	10.6	1.593	16.6	2.343	22.6	4.429	28.6	40.358
4.7	1.211	10.7	1.601	16.7	2.361	22.7	4.495	28.7	46.657
4.8	1.216	10.8	1.610	16.8	2.380	22.8	4.564	28.8	55.283
4.9	1.221	10.9	1.619	16.9	2.400	22.9	4.635	28.9	67.824
5.0	1.226	11.0	1.628	17.0	2.419	23.0	4.707	29.0	87.724
5.1	1.231	11.1	1.636	17.1	2.439	23.1	4.783	29.1	124.152
5.2	1.236	11.2	1.645	17.2	2.459	23.2	4.862	29.2	212.319
5.3	1.242	11.3	1.655	17.3	2.479	23.3	4.943	29.3	732.500
5.4	1.247	11.4	1.664	17.4	2.500	23.4	5.026		
5.5	1.252	11.5	1.673	17.5	2.521	23.5	5.112		
5.6	1.257	11.6	1.682	17.6	2.542	23.6	5.200		
5.7	1.263	11.7	1.692	17.7	2.564	23.7	5.293		
5.8	1.268	11.8	1.702	17.8	2.586	23.8	5.388		
5.9	1.273	11.9	1.712	17.9	2.609	23.9	5.487		

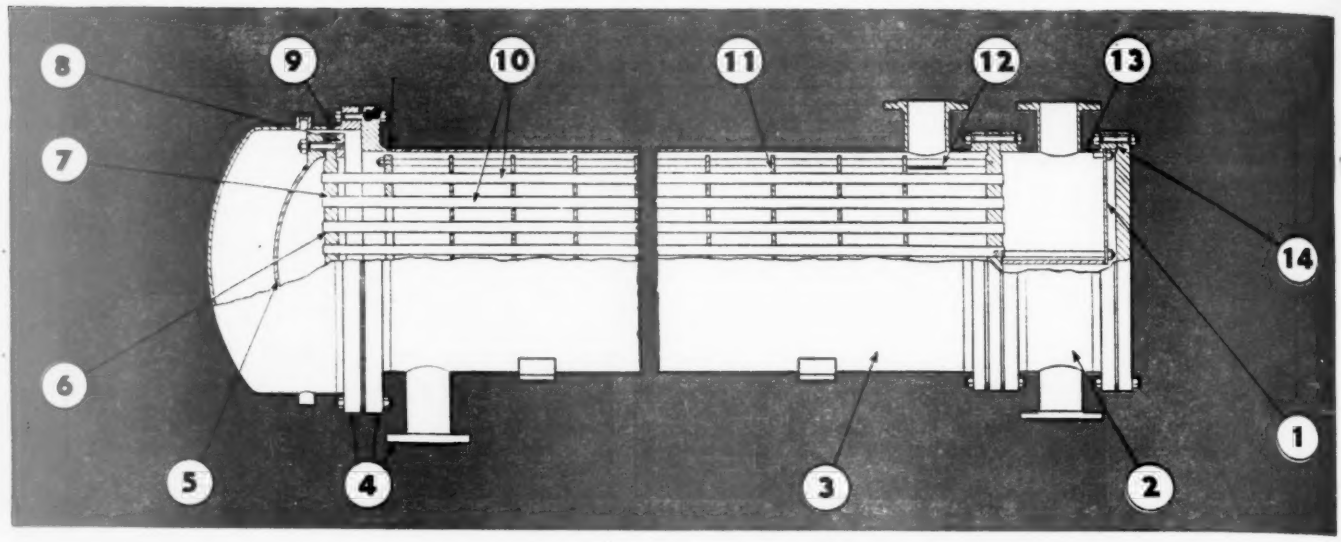
Factors: The tables above are for use in determining the number of cu. ft. to pass through a positive meter, on a physical test car, at various pressures (vacuum), to equal cu. ft. at 14.65 lb. abs. (4 oz. + 14.4).

$$\text{Factor} = \frac{14.65 \text{ lb.}}{14.4 \text{ lb.} - (\text{In. Vac.} \times 0.4908)}$$

Example: If 13.2 cu. ft. is the volume of gas to be passed through a positive meter on a physical test car, when the temperature is 60°F., and 4-oz. pressure is held on the meter, what will be the correct number of cu. ft. to pass if the pressure on the meter is 10-in. vacuum instead of 4-oz. pressure?

Factor for 10-in. vacuum (from above table) is 1.543.

$13.2 \times 1.543 = 20.3676$ cu. ft. to pass through the positive meter with 10-in. vacuum pressure to give 13.2 cu. ft. at 4-oz. pressure.



WHY G-R VANEFLO EXCHANGERS

Note these 14 advantageous features

1. Patented partition sealing plate eliminates staybolts and leaks between passes in heads.
2. Large variety of stationary head arrangements to meet conditions of service.
3. Shells strong, ductile, welding-quality steel plate.
4. Jigs and fixtures assure accurate positioning and alignment of welded nozzles and flanges.
5. Floating heads prevent temperature stresses.
6. Tube holes in tube sheets drilled and reamed for proper tube seating.
7. Patented Multi-groove tube joint assures maximum strength and lasting tightness.
8. Patented split-ring joint permits largest tube bundle for given size shell.
9. All welding by experienced men. Welding shop approved by leading insurance companies.
10. Triangular tube spacing for clean fluids; square pitch for cleaning lanes when required.
11. Variety of baffle designs for minimum pressure drop on any service.
12. Baffles opposite shell nozzles prevent dead spaces at ends of unit.
13. Stationary head channel extra heavy with ample reinforcement around nozzle openings.
14. Any type gasketed joint and gasket material may be supplied.

give best service wherever shell-and-tube heat transfer apparatus is required.

In the drawing above are pointed out 14 advantageous features . . . many of them exclusive . . . in G-R Vaneflo Heat Exchangers.

Some of these features assure **greatest effectiveness** . . . maximum heat transfer rates for allowable pressure drop. Others maintain **freedom from trouble** . . . absence of expansion and contraction strains or security against leakage between fluids or failure of joints. And others provide **convenience** . . . ready access for inspection and cleaning.

These are some of the reasons for the outstanding popularity of G-R Shell-and-Tube Heat Exchangers . . . designed for today's requirements and backed by three quarters of a century of experience in solving heat transfer problems of every kind in every industry. Write for Bulletin 915 describing G-R Vaneflo Exchangers in greater detail.

THE GRISCOM-RUSSELL CO.
285 Madison Avenue New York 17, N. Y.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Static Press. 2400-2495-lb.

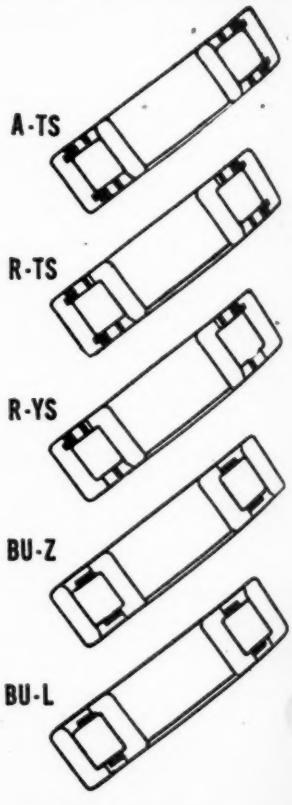
Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	2400	2405	2410	2415	2420	2425	2430	2435	2440	2445	2450	2455	2460	2465	2470	2475	2480	2485	2490	2495
2	69.48	69.55	69.64	69.71	69.78	69.85	69.92	69.99	70.06	70.13	70.21	70.28	70.35	70.42	70.49	70.56	70.63	70.70	70.77	70.84
4	98.28	98.38	98.50	98.60	98.70	98.80	98.90	99.00	99.10	99.20	99.30	99.40	99.50	99.60	99.70	99.80	99.60	100.0	100.1	100.2
6	120.4	120.5	120.7	120.8	120.9	121.0	121.1	121.3	121.4	121.5	121.6	121.8	121.9	122.0	122.1	122.3	122.4	122.5	122.6	122.7
8	139.0	139.2	139.3	139 5	139.6	139 7	139.9	140.0	140.2	140.3	140.5	140.6	140.7	140.9	141.0	141.2	141.3	141.4	141.6	141.7
10	155.4	155.5	155.7	155.8	156.0	156.2	156.4	156.5	156.7	156.8	156.9	157.1	157.3	157.5	157.6	157.8	157.9	158.1	158.3	158.4
12	170 2	170.4	170.6	170.8	170.9	171.1	171.3	171.5	171.6	171.8	171.9	172.2	172.3	172.5	172.7	172.8	173.0	173.2	173.4	173.6
14	183 9	184.1	184.3	184.5	184.7	184.8	185.0	185.2	185.4	185.6	185.8	185 9	186.2	186.3	186.5	186.7	186.9	187.1	187.3	187.5
16	196.6	196.8	197.0	197.2	197 4	197 6	197 8	198 0	198.2	198.4	198.6	198.8	199.0	199 2	199.4	199.6	199 8	200.0	200 2	200.4
18	208.5	208.7	208.9	209 2	209.4	209.6	209.8	210.0	210.2	210.4	210.7	210.9	211.1	211.3	211.5	211.7	211.9	212.1	212.4	212.6
20	219.7	219.9	220.2	220.5	220.7	220.9	221.1	221.4	221.6	221.8	222.0	222.3	222.5	222.7	222.9	223.1	223.4	223.6	223.8	224.0
21	225.2	225.4	225.7	225.9	226.2	226.4	226.6	226.7	227.1	227.3	227.5	227.8	228.0	228.2	228.5	228.7	228.9	229.1	229.4	229.6
22	230.5	230.7	230 9	231.2	231.4	231 7	231.9	232.2	232.4	232.6	232.9	233.1	233.3	233.6	233.8	234.0	234.3	234.5	234.7	234.9
23	235.7	235.9	236.2	236.4	236.7	236.9	237.2	237.4	237.6	237.9	238.1	238.4	238.6	238.8	239.1	239.3	239.6	239.8	240.0	240.3
24	240.7	240.9	241.3	241.5	241.8	242.0	242.3	242.5	242.7	242.9	243.2	243.5	243.7	243.9	244.2	244.5	244.7	244.9	245.2	245.4
25	245.7	245.9	246.2	246.5	246.7	247.0	247.2	247.5	247.7	248.0	248.2	248.5	248.7	249.0	249.2	249.5	249.7	250.0	250.2	250.5
26	250.6	250.8	251.1	251.4	251.6	251.9	252.1	252.4	252.7	252.9	253 2	253.4	253.7	253 9	254.2	254.4	254.7	254.9	255.2	255.5
27	255.3	255.6	255.9	256.2	256.4	256.7	256.9	257.2	257.5	257.7	257 9	258.2	258.5	258.8	259.0	259.3	259 5	259.8	260.1	260.3
28	260.0	260.3	260.6	260.9	261.2	261.4	261.7	261.9	262.2	262.5	262.7	263.0	263.3	263.5	263.8	264.1	264.3	264.6	264.9	265.1
29	264.6	264.9	265.2	265.5	265.7	266.0	266.3	266.6	266.8	267.1	267.4	267.6	267.9	268.2	268.4	268.7	268.9	269.2	269.5	269.8
30	269.1	269.4	269.7	270.0	270.3	270.6	270.8	271.1	271 4	271.7	271.9	272.2	272.5	272.7	273.0	273.3	273.6	273.8	274.1	274.4
31	273.6	273.9	274.2	274.5	274.8	275.1	275.3	275.6	275.9	276.2	276.4	276.7	277.0	277.3	277.6	277.8	278.1	278.4	278.7	278.9
32	277.9	278.3	278.6	278.9	279.2	279.5	279.7	280.0	280 3	280.6	280.9	281.1	281 4	281.7	282.0	282.3	282.6	282.8	283.1	283.4
33	282.3	282.6	282.9	283.2	283.5	283.8	284.1	284.4	284 7	284.9	285.2	285 5	285 8	286 1	286.4	286.7	286.9	287.2	287 5	287.8
34	286.5	286.8	287 2	287.5	287.8	288.0	288.3	288.6	288.9	289.2	289.5	289.8	290.1	290.4	290.7	290.9	291.3	291.5	291.8	292.1
35	290.7	291.0	291 4	291.7	291.9	292.2	292.5	292.8	293.1	293.4	293.7	294.0	294.3	294.6	294.9	295.2	295.5	295.8	296.1	296.4
36	294.8	295.1	295.5	295.8	296.1	296.4	296.7	297.0	297.3	297.6	297.9	298.2	298.5	298.8	299.1	299.4	299.7	300.0	300.3	300.6
37	298 9	299.2	299 6	299.9	300.2	300.5	300.8	301.1	301 4	301.7	302.0	302 3	302.6	302.9	303.2	303.5	303.8	304.1	304.4	304.8
38	302.9	303.2	303.6	303.9	304.2	304.5	304.8	305.1	305.4	305.7	306.0	306.3	306.7	306.9	307.3	307.6	307.9	308 2	308.5	308.8
39	306.9	307.2	307.6	307.9	308.2	308.5	308.8	309.1	309.4	309.7	310.1	310 4	310.7	311.0	311.3	311.6	311.9	312.2	312.6	312.9
40	310.8	311.1	311.5	311.8	312.1	312.5	312.8	313.1	313.4	313.7	314.0	314.3	314.7	314.9	315.3	315.6	315.9	316.2	316.6	316.9
41	314.6	314.9	315.3	315.7	315.9	316.3	316.6	316 9	317.3	317.6	317.9	318.2	318.5	318.9	319.2	319.5	319.8	320.1	320.5	320.8
42	318.5	318.8	319.2	319.5	319.8	320.2	320.5	320.8	321.1	321.5	321.8	322.1	322.4	322.7	323.1	323.4	323.7	324.0	324.4	324.7
43	322.2	322.5	322.9	323.3	323.6	323.9	324.2	324.6	324.9	325.2	325.6	325.9	326.2	326.5	326 9	327 2	327.5	327.8	328.2	328.5
44	325.9	326.3	326.7	327 0	327.3	327.7	328.0	328.3	328.7	329.0	329.3	329.7	329.9	330.3	330.7	330.9	331.3	331.6	331 9	332.3
45	329.6	329.9	330.4	330.7	331.0	331.4	331.7	332.0	332.4	332.7	333.0	333.4	333.7	334.1	334.4	334.7	335.1	335.4	335.7	336.1
46	333.3	333.6	334 0	334.3	334.7	335.0	335.4	335.7	336.0	336.4	336.7	337.1	337.4	337.7	338.1	338.4	338.8	339.1	339.4	339.8
47	336 9	337.2	337.7	338.0	338 3	338.7	339.0	339.4	339.7	340.1	340.4	340.7	341.1	341.4	341.8	342.1	342.5	342.8	343.1	343.5
48	340.4	340.8	341.2	341.5	341.9	342.2	342.6	342.9	343.3	343.6	343.9	344.3	344.7	345.0	345.4	345.7	346.0	346.4	346.7	347.1
49	343.9	344.3	344.7	345.1	345.4	345.8	346.1	346 5	346.8	347.2	347.5	347.9	348.2	348.6	348 9	349.3	349.6	350.0	350.3	350.7
50	347.5	347.8	348.2	348.6	348.9	349.3	349.7	350.0	350.4	350.7	351.1	351.4	351.8	352.1	352.5	352.8	353.2	353.5	353.9	354.2
51	350.9	351.3	351.7	352.0	352.4	352.8	353.1	353.5	353.8	354.2	354 5	354.9	355.3	355.6	355 9	356.3	356.7	357.0	357.4	357.8
52	354 3	354.7	355 1	355.5	355.9	356.2	356.6	356 9	357.3	357.7	358.0	358.4	358.7	359.1	359.5	359.8	360.2	360.5	360.9	361.3
53	357.7	358.1	358.5	358 9	359 3	359.6	360.0	360.4	360.7	361.1	361.4	361.8	362.2	362.5	362.9	363.3	363 6	364.0	364.4	364.7
54	361.1	361.4	361.9	362.3	362 6	362.9	363.4	363.7	364.1	364.5	364.8	365.2	365.6	365.9	366.3	366.7	367.0	367.4	367.8	368.1
55	364.4	364.8	365.2	365.6	365.9	366.3	366.7	367.1	367.5	367.8	368.2	368.6	368.9	369.3	369.7	370.1	370.4	370.8	371.2	371.5
56	367.7	368.1	368.5	368.9	369.3	369.7	370 0	370.4	370.8	371.2	371.5	371.9	372.3	372.6	373.0	373.4	373.8	374.1	374.5	374.9
57	371.0	371.4	371.8	372.2	372.6	372.9	373.3	373.7	374.1	374.5	374.9	375.2	375.6	375.9	376.4	376.7	377.1	377.5	377.9	378.3
58	374.2	374.6	375 1	375.5	375.8	376.2	376.6	376 9	377.4	377.7	378.1	378.5	378.9	379 3	379.7	380.0	380.4	380.8	381.2	381.6
59	377.4	377.8	378.3	378.7	379.1	379.4	379.8	380.2	380.6	380.9	381.4	381.7	381.1	382.5	382.9	383.3	383.7	384.0	384.4	384.8
60	380.6	381.0	381.5	381.9	382.3	382.6	383.0	383.4	383.8	384.2	384.6	384.9	385.4	385.7	386.1	386.5	386.9	387.3	387.7	388.1
61	383.8	384.2	384.6	385.0	385.4	385.8	386.2	386.6	386.9	387.4	387.8	388.2	388.5	388.9	389.3	389.7	390.1	390.5	390.9	391.3
62	386.9	387.3	387.8	388.2	388.6	388.9	389.4	389.8	390.2	390.5	390.9	391.3	391.7	392.1	392.5	392.9	393.3	393.7	394.1	394.5
63	390.0	390.4	390.9	391.3	391.7	392.1	392.5	392.9	393.3	393.7	394.1	394.5	394.9	395 3	395.7	396.1	396.4	396.8	397.2	397.6
64	393.1	393.5	394.0	394.4	394.8	395.2	395.6	396 0	396.4	396.8	397.2	397.6	398.0	398.4	398.8	399.2	399.6	400.0	400.4	400.8
65	396.2	396.6	397.0	397.5	397.9	398.3	398.7	399.1	399.5	399.9	400.3	400.7	401.1	401.5	401.9	402.3	402.7	403.1	403.5	403.9
66	399.2	399.6	400.1	400 5	400.9	401.3	401.7	402.1	402.5	402.9	403.4	403.8	404.2	404.6	404.9	405.4	405.8	406.2	406.6	407.0
67	402 2	402.6	403.1	403.5	403 9	404.3	404.7	405 2	405.6	405 9	406.4	406.8	407.2	407.6	408.0	408.4	408.8	409.2	409 7	410.1
68	405.2	405.6	406.1	406.5	406.9	407.3	407.8	408.2	408.6	409.0	409.4	409.8	410.2	410.6	411.1	411.5	411.9	412 3	412.7	413.1
69	408.2	408.6	409.1	409 5	409 9	410.4	410.8	411.2	411.6	412.0	412.4	412.9	413.3	413.7	414.1	414.5	414.9	415 3	415.8	416.2
70	411.1	411.6	412.1	412.5	412.9	413.3	413.7	414.2	414.6	415.0	415.4	415.8	416.3	416.7	417.1	417.5	417.9	418.3	418.8	419.2
71	414 0	414.5	414.9	415.4	415.8	416.2	416.7	417.1	417.5	417.9	418.3	418.8	419.2	419.6	420.0	420.5	420.9	421.3	421.7	422.1
72	416.9	417.4	417.9	418.3	418.7	419.2	419.6	420.0	420.4	420.9	421.3	421.7	422.1	422.5	422.9	423.4	423.8	424.2	424.7	425.1
73	419.8	420.3	420.8	421.2	421.6	422.1	422.5	422.9	423.4	423.8	424.2	424.6	425.1	425.5	425.9	426.3	426.8	427.2	427.6	428.0
74	422.7	423.1	423 6	424.1	424.5	424.9	425.4	425.8	426.2	426.7	427.1	427.5	427.9	428.4	428.8	429.2	429.7	430.1	430.5	430.9
75	425.5	425.9	426.5	426.9	427.4	427.8	428.2	428.7	429.1	429.5	429 9	430.4	430.8	431.3	431.7	432.1	432.6	433.0	433.4	433.9
76	428.4	428.8	429.4	429.8	430.2	430.7	431.1	431.5	431.9	432.4	432.8	433.3	433.7	434.1	434.6	435.0	435.5	435.9	436.3	436.8
77	431.2	431.6	432.2	432.6	433 0	433.5	433.9	434.4	434.8	435.2	435.7	436.1	436.6	437.0	437.4	437.9	438.3	438.7	439.2	439.6
78	434.0	434.4	434.9	435.4	435.9	436.4	436.7	437.2	437.6	438.1	438.5	438.9	439.4	439.8	440.3	440.7	441.2	441.6	442.0	442.5
79	436.8	437.2	437.7	438.2	438.6	439.1	439.5	439.9	440.4	440.8	441.3	441.7	442.2	442.6	443.1	443.5	443.9	444.4	444.8	445.3
80	439.5	439 9	440.5	440.9	441.4	441.8	442.3	442.7	443.2	443.6	444.1	444.5	444.9	445.4	445.9	446.3	446.7	447.2	447.6	448.1
81	442.3	442.7	443.2	443.7	444.1	444.6	445.0	445.5	445.9	446.4	446.8	447.3	447.7	448.2	448.6	449.1	449.5	450.0	451.4	451.9
82	444.9	445.4	445.9	446.4	446.9	447.3	447.8	448.2	448.7	449.1	449.6	450.0	450.5	450.9	451.4	451.8	452.3	452.7	453.2	453.7
83	447.7	448.1	448.7	449.1	449.6	450.0	450.5	450 9	451.4	451.9	452.3	452.8	453.2	453.7	454.1	454.6	455.0	455.5	455.9	456.4
84	450.4	450.8	451.4	451.8	452.3	452.7	453.2	453.8	454.1	454.6	455.0	455.5	455.9	456.4	456.9	457.3	457.8	458.2	458.7	459.2
85	453.1	453 5	454.1	454.5	455.0	455.5	455.9	456.4	456.8	457.3	457.8	458.2	458.7	459.2	459.6	460.1	460.5	461.0	461.5	461.9
86	455.7	456.2	456.7	457.2	457.7	458.1	458.6	459.1	459.5	459.9	460.4	460.9	461.4	461.8	462.3	462.8	463.2	463.7	464.2	464.6
87	458.3	458.8	459.3	459.8	460.4	460.7	461.2	461.7	462.1	462.6	463.1	463.5	464.0	464.5	464.9	465.4	465.9	466.3	466.8	467.3
88	460.9	461.4	462.0	462.5	462.9	463.4	463.9	464.4	464.8	465 3	465.8	466.2	466.7	467.2	467.6	468.1	468.6	469.0	469.5	469.9
89	463.6	464.1	464.6	465.1	465.6	466.0	466.5	466.9	467.4	467.9	468.4	468 9	469.3	469.8	470.3	470.8	471 2	471.7	472.2	472.6
90	466.2	466 7	467.2	467.7	468.2	468.7	469.1	469.6	470.1	470.6	471.0	471.5	471.9	472.4	472.9	473.4	473.9	474.3	474.8	475.3
91	468.7	469.2	469 8	470.3	470.7	471.2	471.7	472.2	472.7	473.1	473.6	474.1	474.6	475.0	475.5	476.0	476.5	476.9	477.4	477.9
92	471.3	471.8	472.4	472.9	473.4	473.8	474.3	474.8	475.3	475.8	476.2	476.7	477.2	477.7	478.2	478.7	479.1	479.6	480.1	480.6
93	473.9	474.4	474.9	475.4	475.9	476.4	476.9	477.4	477.7	478.3	478.8	479.3	479.9	480.3	480.7	481.2	481.7	482.2	482.7	483.2
94	476.4	476.9	477.5	477.9	478.4	478 9	479.4	479.9	480.4	480.7	481.3	481.8	482.3	482.8	483.3	483.8	484.3	484.7	485.2	485.7
95	478.9	479.4	479.0	480.5	481.0	481.5	482.0	482.5	482.9	483.4	483.9	484.4	484.9	485.4	485.9	486.4	486.9	487.3	487.9	488.3
96	481.5	481.9	482.5	483.0	483 5	484 0	484.5	485.0	485.5	485.9	486.5	486.9	487.4	487 9	488.4	488.9	489.4	489.9	490.4	490.9
97	483.9	484.3	485.1	485.6	486.0	486.5	487.0	487.5	488.0	488.5	489.0	489.5	489.9	490.5	490.9	491.5	491.9	492.4	492.9	493 4
98	486 4	486.9	487.5	488.0	488.5	489.0	489.5	490.0	490.5	490.0	491.5	491.9	492.5	492.9	493.5	493.9	494.5	494.9	495.4	495.9
99	488.9	489.4	490.0	490.5	491.0	491.5	492.0	492.5	493.0	493.5	494.0	494.5	495.0	495.5	496.0	496.5	497.0	497.5	498.0	498.5
100	491.4	491.9	492.5	493.0	493.5	494.0	494.5	495.0	495.5	496.0	496.5	497.0	497.5	498.0	498.5	499.0	499.5	500.0	500.5	501.0

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.
Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.
Table has been condensed to serve field men in approximating meter readings. Intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

Hyatt **Hy-Load Bearings** are made in separable types as well as in self-contained units. In the separable bearings the inner races are the separable units in one instance and the outer races in the other. Thus, the component parts of every separable Hyatt Hy-Load type bearing of a given size are fully interchangeable. Every race fits every roller assembly.

Separable races may be assembled in one part of the shop and the rest of the bearing in another. When the sub-assemblies are brought together on the final assembly line the component bearing parts will fit correctly. No selection or matching required.

Every Hyatt A-TS, R-TS, R-YS, BU-Z and BU-L type bearing has this feature—and many others. Write for data.



HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION

Harrison, New Jersey • Chicago • Detroit • Pittsburgh • Oakland, California

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Static Press. 2560-2595-lb.

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	2500	2505	2510	2515	2520	2525	2530	2535	2540	2545	2550	2555	2560	2565	2570	2575	2580	2585	2590	2595
2	70.91	70.98	71.05	71.12	71.19	71.27	71.34	71.41	71.48	71.55	71.62	71.69	71.76	71.83	71.90	71.97	72.04	72.10	72.17	72.24
4	100.3	100.4	100.5	100.6	100.7	100.8	100.9	101.0	101.1	101.2	101.3	101.4	101.5	101.6	101.7	101.8	101.9	102.0	102.1	102.2
6	122.9	122.9	123.1	123.2	123.4	123.5	123.6	123.7	123.8	123.9	124.1	124.2	124.3	124.5	124.6	124.7	124.8	124.9	125.0	125.2
8	141.9	142.0	142.2	142.3	142.4	142.6	142.7	142.9	143.0	143.1	143.3	143.4	143.6	143.7	143.8	144.0	144.1	144.2	144.4	144.5
10	158.6	158.7	158.9	159.0	159.2	159.4	159.5	159.7	159.8	160.0	160.2	160.3	160.5	160.6	160.8	160.9	161.1	161.2	161.4	161.5
12	173.7	173.9	174.1	174.2	174.4	174.6	174.8	174.9	175.1	175.3	175.4	175.6	175.8	175.9	176.1	176.3	176.5	176.6	176.8	176.9
14	187.7	187.8	188.0	188.2	188.4	188.6	188.8	188.9	189.2	189.3	189.5	189.7	189.9	190.1	190.3	190.5	190.6	190.8	190.9	191.2
16	200.6	200.8	201.0	201.2	201.4	201.6	201.8	202.0	202.2	202.4	202.6	202.8	203.0	203.2	203.4	203.6	203.8	203.9	204.2	204.4
18	212.8	213.0	213.2	213.4	213.6	213.8	214.1	214.3	214.5	214.7	214.9	215.1	215.3	215.5	215.8	215.9	216.2	216.3	216.6	216.8
20	224.3	224.5	224.7	224.9	225.2	225.4	225.6	225.8	226.1	226.3	226.5	226.7	226.9	227.2	227.4	227.6	227.8	228.0	228.2	228.5
21	229.8	230.1	230.3	230.5	230.7	230.9	231.2	231.4	231.7	231.9	232.1	232.4	232.6	232.8	233.0	233.3	233.5	233.7	233.9	234.1
22	235.2	235.4	235.7	235.9	236.1	236.4	236.6	236.8	237.1	237.3	237.5	237.8	238.0	238.2	238.5	238.7	238.9	239.1	239.4	239.6
23	240.5	240.8	241.0	241.2	241.5	241.7	241.9	242.2	242.4	242.7	242.9	243.2	243.4	243.6	243.9	244.1	244.4	244.6	244.8	245.0
24	245.7	245.9	246.1	246.4	246.7	246.9	247.1	247.4	247.6	247.9	248.1	248.4	248.6	248.9	249.1	249.4	249.6	249.8	250.0	250.3
25	250.7	251.0	251.2	251.5	251.7	252.0	252.2	252.5	252.7	253.0	253.2	253.5	253.7	254.0	254.2	254.5	254.7	254.9	255.2	255.4
26	255.7	255.9	256.2	256.5	256.7	256.9	257.2	257.5	257.7	258.0	258.3	258.5	258.8	259.0	259.3	259.5	259.8	260.0	260.2	260.5
27	260.6	260.8	261.1	261.4	261.6	261.9	262.1	262.4	262.7	262.9	263.2	263.4	263.7	263.9	264.2	264.5	264.7	264.9	265.2	265.5
28	265.4	265.7	265.9	266.2	266.4	266.7	266.9	267.2	267.5	267.8	268.0	268.3	268.6	268.8	269.1	269.4	269.6	269.8	270.1	270.4
29	270.1	270.3	270.6	270.9	271.1	271.4	271.7	271.9	272.2	272.5	272.7	273.0	273.3	273.6	273.8	274.1	274.4	274.6	274.8	275.1
30	274.7	274.9	275.2	275.5	275.8	276.0	276.3	276.6	276.9	277.1	277.4	277.7	277.9	278.2	278.5	278.8	279.0	279.3	279.5	279.8
31	279.2	279.5	279.8	280.1	280.3	280.6	280.9	281.2	281.5	281.7	282.0	282.3	282.6	282.8	283.1	283.4	283.7	283.9	284.2	284.5
32	283.7	283.9	284.3	284.5	284.8	285.1	285.4	285.7	285.9	286.2	286.5	286.8	287.1	287.4	287.7	287.9	288.2	288.4	288.7	289.0
33	288.1	288.4	288.7	288.9	289.3	289.5	289.8	290.1	290.4	290.7	290.9	291.3	291.6	291.8	292.1	292.4	292.7	292.9	293.2	293.5
34	292.4	292.7	293.0	293.3	293.6	293.9	294.2	294.5	294.8	295.0	295.3	295.6	295.9	296.2	296.5	296.8	297.1	297.3	297.6	297.9
35	296.7	296.9	297.3	297.6	297.9	298.2	298.5	298.8	299.0	299.3	299.6	299.9	300.2	300.5	300.8	301.1	301.4	301.7	301.9	302.2
36	300.9	301.2	301.5	301.8	302.1	302.4	302.7	303.0	303.3	303.6	303.9	304.2	304.5	304.8	305.1	305.4	305.7	305.9	306.2	306.5
37	305.1	305.4	305.7	305.9	306.3	306.6	306.9	307.2	307.5	307.8	308.1	308.4	308.7	309.0	309.3	309.6	309.9	310.2	310.5	310.8
38	309.1	309.4	309.7	310.0	310.4	310.7	310.9	311.3	311.6	311.9	312.2	312.5	312.8	313.1	313.4	313.7	314.1	314.3	314.6	314.9
39	313.2	313.5	313.8	314.1	314.4	314.7	315.1	315.4	315.7	316.0	316.3	316.6	316.9	317.2	317.6	317.9	318.2	318.4	318.7	319.1
40	317.2	317.5	317.8	318.1	318.5	318.8	319.1	319.4	319.7	320.0	320.4	320.7	320.9	321.3	321.6	321.9	322.3	322.5	322.8	323.1
41	321.1	321.4	321.7	322.1	322.4	322.7	323.0	323.3	323.7	323.9	324.3	324.6	324.9	325.3	325.6	325.9	326.2	326.5	326.8	327.1
42	325.0	325.3	325.7	325.9	326.3	326.6	326.9	327.3	327.6	327.9	328.3	328.6	328.9	329.2	329.6	329.9	330.2	330.5	330.8	331.1
43	328.8	329.2	329.5	329.8	330.1	330.5	330.8	331.1	331.5	331.8	332.1	332.4	332.8	333.1	333.4	333.7	334.1	334.3	334.7	335.0
44	332.6	332.9	333.3	333.6	333.9	334.3	334.6	334.9	335.3	335.6	335.9	336.3	336.6	336.9	337.3	337.6	337.9	338.2	338.5	338.9
45	336.4	336.8	337.1	337.4	337.7	338.1	338.4	338.7	339.1	339.4	339.8	340.1	340.4	340.8	341.1	341.4	341.8	342.0	342.4	342.7
46	340.1	340.5	340.8	341.1	341.5	341.8	342.1	342.5	342.8	343.2	343.5	343.8	344.2	344.5	344.9	345.2	345.5	345.8	346.1	346.5
47	343.8	344.2	344.5	344.9	345.2	345.5	345.9	346.2	346.6	346.9	347.3	347.6	347.9	348.3	348.6	348.9	349.3	349.6	349.9	350.3
48	347.4	347.8	348.1	348.5	348.8	349.2	349.5	349.9	350.2	350.6	350.9	351.2	351.6	351.9	352.3	352.6	352.9	353.3	353.6	353.9
49	351.0	351.4	351.7	352.1	352.4	352.8	353.1	353.5	353.8	354.2	354.5	354.9	355.2	355.6	355.9	356.3	356.6	356.9	357.3	357.6
50	354.6	354.9	355.3	355.7	356.0	356.4	356.7	357.1	357.4	357.8	358.1	358.5	358.8	359.2	359.6	359.9	360.3	360.5	360.9	361.3
51	358.1	358.5	358.8	359.2	359.5	359.9	360.3	360.6	360.9	361.3	361.7	362.0	362.4	362.8	363.1	363.5	363.8	364.1	364.5	364.8
52	361.6	361.9	362.3	362.7	363.1	363.4	363.8	364.2	364.5	364.9	365.2	365.6	365.9	366.3	366.7	367.0	367.4	367.7	368.0	368.4
53	365.1	365.5	365.8	366.2	366.5	366.9	367.3	367.6	368.0	368.4	368.7	369.1	369.5	369.8	370.2	370.5	370.9	371.2	371.6	371.9
54	368.5	368.9	369.2	369.6	369.9	370.3	370.7	371.1	371.4	371.8	372.2	372.5	372.9	373.3	373.6	374.0	374.4	374.7	375.0	375.4
55	371.9	372.3	372.6	373.0	373.4	373.8	374.1	374.5	374.9	375.2	375.6	375.9	376.4	376.7	377.1	377.5	377.8	378.1	378.5	378.9
56	375.3	375.6	376.0	376.4	376.8	377.1	377.5	377.9	378.3	378.6	379.0	379.4	379.8	380.1	380.5	380.9	381.3	381.6	381.9	382.3
57	378.6	379.0	379.4	379.8	380.1	380.5	380.9	381.3	381.6	382.0	382.4	382.8	383.2	383.5	383.9	384.3	384.7	385.0	385.3	385.7
58	381.9	382.3	382.7	383.1	383.5	383.8	384.2	384.6	384.9	385.4	385.7	386.1	386.5	386.9	387.3	387.6	388.0	388.3	388.7	389.1
59	385.2	385.6	385.9	386.3	386.7	387.1	387.5	387.9	388.3	388.7	389.0	389.4	389.8	390.2	390.6	390.9	391.3	391.6	392.0	392.4
60	388.5	388.8	389.2	389.6	390.0	390.4	390.8	391.2	391.6	391.9	392.3	392.7	393.1	393.5	393.9	394.3	394.7	394.9	395.4	395.7
61	391.7	392.1	392.4	392.8	393.2	393.6	394.0	394.4	394.8	395.2	395.6	395.9	396.4	396.7	397.1	397.5	397.9	398.2	398.6	399.0
62	394.9	395.3	395.7	396.1	396.5	396.8	397.2	397.6	398.0	398.4	398.8	399.2	399.6	400.0	400.4	400.8	401.2	401.5	401.9	402.3
63	398.0	398.4	398.8	399.2	399.6	400.0	400.4	400.8	401.2	401.6	402.0	402.4	402.8	403.2	403.6	403.9	404.4	404.7	405.1	405.5
64	401.2	401.6	402.0	402.4	402.8	403.2	403.6	404.0	404.4	404.8	405.2	405.6	406.0	406.4	406.8	407.2	407.6	407.9	408.3	408.7
65	404.3	404.7	405.1	405.5	405.9	406.3	406.7	407.1	407.5	407.9	408.3	408.7	409.1	409.5	409.9	410.4	410.8	411.1	411.5	411.9
66	406.4	406.8	407.2	407.6	408.0	408.4	408.8	409.2	409.7	410.1	410.5	410.9	411.3	411.7	412.1	412.5	412.9	413.2	413.6	414.0
67	410.5	410.9	411.3	411.7	412.1	412.5	412.9	413.3	413.7	414.2	414.6	414.9	415.4	415.8	416.2	416.6	417.0	417.3	417.8	418.2
68	413.5	413.9	414.4	414.8	415.2	415.6	416.0	416.4	416.8	417.2	417.7	418.1	418.5	418.9	419.3	419.7	420.1	420.5	420.9	421.3
69	416.6	417.0	417.4	417.8	418.3	418.8	419.1	419.5	419.9	420.3	420.7	421.2	421.6	422.0	422.4	422.8	423.2	423.6	423.9	424.4
70	419.6	420.0	420.4	420.9	421.3	421.7	422.1	422.5	422.9	423.4	423.8	424.2	424.6	425.0	425.5	425.9	426.3	426.6	427.0	427.5
71	422.6	422.9	423.4	423.8	424.2	424.7	425.1	425.5	425.9	426.4	426.8	427.2	427.6	428.0	428.5	428.9	429.3	429.6	430.1	430.5
72	425.5	425.9	426.4	426.8	427.2	427.6	428.1	428.5	428.9	429.3	429.8	430.2	430.6	431.0	431.5	431.9	432.3	432.6	433.1	433.5
73	428.5	428.9	429.3	429.8	430.2	430.6	431.0	431.5	431.9	432.3	432.7	433.2	433.6	434.0	434.5	434.9	435.3	435.7	436.1	436.5
74	431.4	431.8	432.2	432.7	433.1	433.5	433.9	434.4	434.8	435.3	435.7	436.1	436.5	436.9	437.4	437.8	438.3	438.6	439.0	439.5
75	434.3	434.7	435.2	435.6	436.0	436.5	436.9	437.3	437.8	438.2	438.6	439.1	439.5	439.9	440.4	440.8	441.2	441.6	442.0	442.4
76	437.2	437.6	438.1	438.5	438.9	439.4	439.8	440.3	440.7	441.1	441.6	442.0	442.4	442.9	443.3	443.7	444.2	444.5	444.9	445.4
77	440.1	440.5	440.9	441.4	441.8	442.3	442.7	443.1	443.6	444.0	444.4	444.9	445.3	445.8	446.2	446.6	447.1	447.5	447.9	448.3
78	442.9	443.4	443.8	444.2	444.7	445.1	445.6	446.0	446.5	446.9	447.3	447.8	448.2	448.7	449.1	449.5	449.9	450.3	450.8	451.2
79	445.7	446.2	446.6	447.1	447.5	447.9	448.4	448.8	449.3	449.7	450.2	450.6	451.1	451.5	451.9	452.4	452.8	453.2	453.6	454.1
80	448.5	448.9	449.4	449.9	450.3	450.8	451.2	451.7	452.1	452.6	453.0	453.5	453.9	454.4	454.8	455.2	455.7	456.0	456.5	456.9
81	451.3	451.8	452.2	452.7	453.1	453.6	454.0	454.5	454.9	455.4	455.8	456.3	456.7	457.2	457.6	458.1	458.5	458.9	459.4	459.8
82	454.1	454.6	455.0	455.5	455.9	456.4	456.8	457.3	457.7	458.2	458.6	459.1	459.5	459.9	460.4	460.9	461.3	461.8	462.3	462.7
83	456.9	457.3	457.8	458.2	458.7	459.1	459.6	460.1	460.6	461.0	461.4	461.9	462.3	462.8	463.2	463.7	464.1	464.5	464.9	465.4
84	459.6	460.1	460.5	461.0	461.5	461.9	462.4	462.8	463.3	463.7	464.2	464.7	465.1	465.6	466.0	466.5	466.9	467.4	467.9	468.3
85	462.4	462.8	463.3	463.8	464.2	464.7	465.1	465.6	466.1	466.5	466.9	467.4	467.9	468.4	468.8	469.3	469.8	470.1	470.6	471.0
86	465.1	465.5	466.0	466.5	466.9	467.4	467.9	468.3	468.8	469.3	469.7	470.2	470.7	471.1	471.6	472.0	472.5	472.9	473.3	473.8
87	467.7	468.2	468.7	469.1	469.6	470.1	470.5	471.0	471.5	471.9	472.4	472.9	473.3	473.8	474.3	474.7	475.2	475.6	476.0	476.5
88	470.5	470.9	471.4	471.9	472.3	472.8	473.3	473.7	474.2	474.7	475.1	475.6	476.1	476.5	477.0	477.5	477.9	478.3	478.8	479.3
89	473.1	473.6	474.1	474.5	475.0	475.5	475.9	476.4	476.9	477.4	477.8	478.3	478.8	479.2	479.7	480.2	480.7	481.0	481.5	481.9
90	475.8	476.2	476.7	477.2	477.7	478.1	478.6	479.1	479.6	480.0	480.5	481.0	481.5	481.9	482.4	482.9	483.4	483.8	484.2	484.7
91	478.4	478.9	479.3	479.8	480.3	480.8	481.2	481.7	482.2	482.7	483.1	483.6	484.1	484.6	485.1	485.5	486.0	486.4	486.9	487.3
92	481.0	481.5	482.0	482.5	482.9	483.4	483.9	484.4	484.9	485.4	485.8	486.3	486.8	487.3	487.7	488.2	488.7	489.1	489.6	490.1
93	483.6	484.1	484.6	485.1	485.6	486.1	486.5	487.0	487.5	487.9	488.4	488.9	489.4	489.8	490.4	490.9	491.4	491.8	492.2	492.7
94	486.2	486.7	487.2	487.7	488.1	488.6	489.1	489.6	490.1	490.6	491.0	491.5	492.0	492.5	493.0	493.5	493.9	494.3	494.8	495.3
95	488.8	489.3	489.8	490.3	490.8	491.2	491.7	492.2	492.7	493.2	493.7	494.2	494.7	495.1	495.6	496.1	496.6	497.0	497.5	497.9
96	491.4	491.9	492.3	492.8	493.3	493.8	494.3	494.8	495.3	495.8	496.3	496.8	497.2	497.7	498.2	498.7	499.2	499.6	500.1	500.6
97	493.9	494.4	494.9	495.4	495.9	496.4	496.9	497.4	497.9	498.4	498.8	499.3	499.8	500.3	500.8	501.3	501.8	502.2	502.7	503.2
98	496.4	496.9	497.4	497.9	498.4	498.9	499.4	499.9	500.4	500.9	501.4	501.9	502.4	502.9	503.4	503.9	504.3	504.8	505.3	595.7
99	499 0	499.5	499.9	500.5	500.9	501.5	501.9	502.5	502.9	503.5	503.9	504.5	594.9	505.5	505.9	506.5	506 9	507.3	507.8	508.3
100	501.5	502.0	502.5	503.0	503.5	504.0	504.5	505.0	505.5	506.0	506.5	507.0	507.5	508.0	508.5	509.0	509.5	510.0	510.5	511.0

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.
Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.
Table has been condensed to serve field men in approximating meter readings. Intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

This is Why the Nash is the Most Simple Compressor

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

323 WILSON, SO. NORWALK, CONN.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Static Press. 2600-2695-lb.

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	2600	2605	2610	2615	2620	2625	2630	2635	2640	2645	2650	2655	2660	2665	2670	2675	2680	2685	2690	2695
2	72.31	72.38	72.45	72.52	72.58	72.65	72.72	72.79	72.86	72.93	73.00	73.06	73.13	73.20	73.27	73.34	73.40	73.47	73.54	73.61
4	102.3	102.4	102.5	102.6	102.7	102.8	102.9	103.0	103.1	103.2	103.3	103.4	103.4	103.5	103.6	103.7	103.8	103.9	104.0	104.1
6	125.3	125.4	125.5	125.7	125.8	125.9	126.0	126.1	126.2	126.4	126.5	126.6	126.7	126.8	126.9	127.1	127.2	127.3	127.4	127.5
8	144.7	144.8	144.9	145.1	145.2	145.3	145.5	145.6	145.8	145.9	146.1	146.2	146.3	146.5	146.6	146.7	146.8	146.9	147.1	147.3
10	161.7	161.9	162.0	162.2	162.3	162.5	165.6	162.8	162.9	163.1	163.2	163.4	163.5	163.7	163.8	164.0	164.1	164.3	164.4	164.6
12	177.1	177.3	177.5	177.7	177.8	177.9	178.1	178.3	178.5	178.7	178.8	178.9	179.2	179.3	179.5	179.7	179.8	179.9	180.2	180.3
14	191.4	191.5	191.7	191.9	192.1	192.3	192.4	192.6	192.8	193.0	193.2	193.3	193.5	193.7	193.9	194.1	194.2	194.4	194.6	194.8
16	204.6	204.8	204.9	205.9	205.3	205.5	205.7	205.9	206.1	206.3	206.5	206.7	206.9	207.1	207.3	207.5	207.6	207.8	208.0	208.2
18	216.9	217.2	217.4	217.6	217.8	218.0	218.2	218.4	218.6	218.8	219.1	219.2	219.4	219.7	219.9	220.1	220.3	220.5	220.7	220.9
20	228.7	228.9	229.1	229.4	229.6	229.8	230.0	230.2	230.4	230.7	230.9	231.1	231.3	231.5	231.7	231.9	232.1	232.4	232.6	232.8
21	234.4	234.6	234.8	235.1	235.3	235.5	235.7	235.9	236.2	236.4	236.6	236.8	237.0	237.3	237.5	237.7	237.9	238.1	238.4	238.6
22	239.8	240.1	240.3	240.5	240.7	240.9	241.2	241.4	241.7	241.9	242.1	242.4	242.6	242.8	243.0	243.3	243.5	243.7	243.9	244.2
23	245.3	245.5	245.7	245.9	246.2	246.4	246.7	246.9	247.1	247.4	247.6	247.8	248.0	248.3	248.5	248.7	248.9	249.2	249.4	249.7
24	250.5	250.8	251.0	251.3	251.5	251.7	251.9	252.2	252.4	252.7	252.9	253.1	253.4	253.6	253.9	254.1	254.3	254.5	254.8	255.0
25	255.7	255.9	256.2	256.4	256.6	256.9	257.1	257.4	257.6	257.9	258.1	258.3	258.6	258.8	259.1	259.3	259.5	259.8	260.0	260.3
26	260.8	261.0	261.3	261.5	261.7	261.9	262.2	262.5	262.7	263.0	263.3	263.5	263.7	263.9	264.2	264.5	264.7	264.9	265.2	265.4
27	265.7	265.9	266.2	266.5	266.7	266.9	267.2	267.5	267.7	268.0	268.3	268.5	268.7	269.0	269.3	269.5	269.7	269.9	270.2	270.5
28	270.6	270.9	271.2	271.4	271.6	271.9	272.2	272.4	272.7	272.9	273.2	273.4	273.7	273.9	274.2	274.5	274.7	274.9	275.2	275.5
29	275.4	275.7	275.9	276.2	276.4	276.7	276.9	277.2	277.5	277.8	278.0	278.2	278.5	278.8	279.0	279.3	279.5	279.8	280.1	280.3
30	280.1	280.4	280.6	280.9	281.1	281.4	281.7	281.9	282.2	282.5	282.8	283.0	283.3	283.5	283.8	284.1	284.3	284.6	284.9	285.1
31	284.7	285.0	285.3	285.6	285.8	286.1	286.4	286.6	286.9	287.2	287.5	287.7	287.9	288.3	288.5	288.8	289.0	289.3	289.6	289.9
32	289.3	289.6	289.9	290.1	290.4	290.7	290.9	291.2	291.5	291.8	292.1	292.3	292.6	292.9	293.1	293 4	293.6	293.9	294.2	294.5
33	293.8	294.1	294.4	294.7	294.9	295.2	295.5	295.7	296.0	296.3	296.6	296.8	297.1	297.4	297.7	297.9	298.2	298.5	298.8	299.1
34	298.2	298.5	298.8	299.1	299.3	299.6	299.9	300.2	300.5	300.8	301.0	301.3	301.6	301.9	302.2	302.4	302.7	302.9	303.3	303.6
35	302.5	302.8	303.1	303.4	303.7	303.9	304.3	304.7	304.9	305.1	305.4	305.7	306.0	306.3	306.6	306.9	307.1	307.4	307.7	307.9
36	306.8	307.1	307.4	307.7	308.0	308.3	308.6	308.9	309.2	309.5	309.8	310.0	310.3	310.6	310.9	311.2	311.5	311.8	312.1	312.4
37	311.1	311.4	311.7	312.0	312.2	312.5	312.8	313.1	313.5	313.8	314.1	314.3	314.6	314.9	315.2	315.5	315.8	316.1	316.4	316.7
38	315.2	315.5	315.8	316.1	316.4	316.7	317.0	317.3	317.6	317.9	318.2	318.5	318.8	319.1	319.4	319.7	320.0	320.3	320.6	320.9
39	319.4	319.7	320.0	320.3	320.6	320.9	321.2	321.5	321.8	322.1	322.4	322.7	323.0	323.3	323.6	323.9	324.2	324.5	324.8	325.1
40	323.5	323.8	324.1	324.4	324.7	325.0	325.3	325.6	325.9	326.2	326.6	326.8	327.1	327.4	327.8	328.1	328.3	328.6	328.9	329.3
41	327.4	327.8	328.1	328.4	328.7	329.0	329.3	329.6	329.9	330.3	330.6	330.9	331.2	331.5	331.8	332.1	332.4	332.7	333.0	333.3
42	331.4	331 8	332 1	332.4	332.7	333.0	333.3	333.6	333.9	334 3	334.6	334.9	335.2	335.5	335.8	336.1	336.4	336.7	337.1	337.4
43	335.3	335.6	335 9	336.3	336.6	336.9	337.2	335.5	337.9	338.2	338.5	338.8	339.1	339.5	339.8	340.1	340.4	340.7	341 0	341.4
44	339.2	339.5	339.9	340.2	340.5	340.8	341.1	341.5	341.8	342.1	342 5	342 8	343.1	343.4	343.7	344.1	344.3	344.6	344.9	345.3
45	343.0	343.4	343.7	344.0	344.3	344.7	345.0	345.3	345.7	346.0	346.3	346.6	346.9	347.3	347.6	347.9	348.2	348.5	348.9	349.2
46	346.8	347.1	347.5	347.8	348.1	348.5	348.8	349.1	349.5	349.8	350.1	350.4	350.8	351.1	351.4	351.8	352.0	352.4	352.7	353.1
47	350.6	350.9	351.3	351.6	351.9	352.3	352.6	352.9	353.3	353.6	353.9	354.2	354 6	354.9	355.3	355.6	355.9	356.2	356.6	356.9
48	354 3	354.6	354.9	355.3	355.6	355.9	356.3	356.6	357.0	357.3	357.7	358.0	358.3	358.7	359.0	359.4	359 6	359.9	360.3	360.7
49	357.9	358.3	358.7	359.0	359.3	359.7	360.0	360.4	360.7	361.1	361.4	361.7	362.0	362.4	362.7	363.1	363.4	363.7	364.1	364.4
50	361.6	361.9	362.3	362.7	362.9	363.3	363.7	364.0	364.4	364.7	365.1	365.4	365.7	366.1	366.4	366.8	367.1	367.4	367.8	368.1
51	365.2	365.5	365.9	366.3	366.5	366.9	367.3	367.6	367.9	368.3	368.7	369.0	369.3	369.7	370 0	370.4	370.7	371.0	371.4	371.8
52	368.8	369.1	369.5	369.8	370.1	370.5	370.9	371.2	371.6	371.9	372.3	372.6	372.9	373.3	373.7	374.0	374.3	374.7	375.0	375.4
53	372.3	372.7	373.0	373.4	373.7	374.0	374.4	374.8	375.1	375.5	375.9	376.2	376.5	376.9	377.2	377 6	377.9	378.3	378.6	379 0
54	375.8	376.1	376.5	376.9	377.2	377.5	377.9	378.3	378.6	379.0	379.4	379.7	380.0	380.4	380.8	381.1	381.4	381.8	382.2	382.5
55	379.2	379.6	380.0	380.4	380.7	381.0	381.4	381.8	382.1	382.5	382.9	383.2	383.6	383.9	384.3	384.7	384.9	385.3	385.7	386.1
56	382.7	383.0	383.4	383.8	384.1	384 5	384.8	385.2	385.6	385.9	386.3	386.6	387.0	387.4	387.8	388.1	388.4	388.8	389 2	389.6
57	386.1	386.5	386.9	387.2	387.5	387.9	388.3	388.7	389 0	389.4	389.8	390.1	390.5	390.9	391.2	391.6	391.9	392 3	392.7	393.0
58	389.5	389.9	390.2	390.6	390.9	391 3	391.7	392.1	392.4	392.8	393 2	393 5	393.9	394.3	394.7	395.0	395 3	395.7	396.1	396.5
59	392.8	393.2	393.6	393.9	394.3	394 6	395.0	395.4	395.8	396.2	396.6	396 9	397.3	397.6	398.0	398.4	398.7	399.1	399.5	399.9
60	396.1	396.5	396.9	397.3	397.6	397.9	398.4	398.8	399 1	399 5	399.9	400.2	400.6	401.0	401.4	401.8	402.1	402.5	402.9	403.3
61	399.4	399.8	400.2	400.6	400.9	401.3	401.7	402.1	402 4	402.8	403.2	403.5	403.9	404.3	404.7	405.1	405.4	405 8	406.2	406.6
62	402.7	403.1	403.5	403.9	404.2	404.6	404.9	405.3	405.7	406.1	406.5	406.8	407.2	407.6	408.0	408.4	408.7	409.1	409 5	409.9
63	405.9	406.3	406.7	407.1	407.4	407.8	408.2	408.6	409.0	409.4	409.8	410.1	410 5	410.9	411.3	411.7	412.0	412.4	412.8	413.2
64	409.1	409.5	409.9	410.3	410.6	411.0	411.4	411.8	412.2	412.6	413.0	413.4	413.8	414.2	414.6	414.9	415.3	415.7	416.1	416.5
65	412.3	412.7	413.1	413.5	413.8	414.2	414.6	415.0	415.4	415.8	416.2	416.6	416.9	417.4	417.8	418.2	418.5	418.9	419.3	419.7
66	415.5	415.9	416.3	416.7	417.1	417.5	417.8	418 2	418.6	419.0	419.4	419.8	420 2	420.6	420.9	421.4	421.7	422.1	422.5	422.9
67	418.6	418.9	419.4	419.8	420.1	420.5	420.9	421.4	421.8	422.2	422.6	422.9	423.3	423.7	424.1	424.6	424.9	425.3	425.7	426.1
68	421.7	422.1	422.5	422.9	423.3	423.7	424.1	424.5	424.9	425.3	425.7	426.1	426.5	426.9	427.3	427.7	428.0	428.5	428.9	429.3
69	424.8	425.2	425.6	426.1	426.4	426.8	427 2	427.6	428.1	428.5	428.9	429 2	429.6	430.0	430.5	430.9	431.3	431.7	432.1	432.5
70	427.9	428.3	428.7	429.1	429.5	429.9	430.3	430.7	431.1	431.6	431.9	432.3	432.7	433.2	433.6	434.0	434.3	434.7	435.2	435.6
71	430 9	431.3	431.7	432.2	432.5	432.9	433.3	433.8	434.2	434.6	435.0	435.4	435.8	436.2	436.6	437.1	437.4	437.8	438.2	438.7
72	433.9	434.3	434.8	435.2	435.5	435.9	436 4	436.8	437.2	437.7	438.1	438.4	438.8	439.3	439.7	440.1	440.5	440.9	441.3	441.7
73	436.9	437.3	437.8	438.2	438.6	438.9	439.4	439.8	440.3	440.7	441.1	441.5	441.9	442.3	442.7	443.1	443 5	443 9	444.4	444.8
74	439.9	440.3	440.8	441.2	441.5	441.9	442.4	442.8	443.3	443.7	444.1	444.5	444.9	445.3	445.8	446.2	446.5	446.9	447.4	447.8
75	442.9	443.3	443.7	444.2	444.5	444.9	445.4	445.8	446.2	446.7	447.1	447.5	447.9	448.3	448.8	449.2	449.5	449.9	450.4	450.8
76	445.8	446.3	447.7	447.1	447.5	447.9	448.4	448.8	449 2	449.7	450.1	450.5	450.9	451.3	451.8	452.2	452.5	452.9	453.4	453.9
77	448.7	449.2	449.6	450.1	450.4	450.9	451.3	451.7	452.2	452.6	453.0	453.4	453.8	454.3	454.7	455.2	455.5	455.9	456.4	456.8
78	451.7	452.1	452.5	452 9	453.3	453.8	454.2	454.7	455.1	455.5	456.0	456.3	456.8	457.2	457.7	458.1	458.5	458.9	459.3	459.8
79	454.5	454.9	455.4	455.9	456.2	456.7	457.1	457.5	458.0	458.4	458.9	459.2	459.7	460.1	460.6	461.0	461.4	461.8	462.3	462.7
80	457.4	457.8	458.3	458.7	459.1	459.5	459.9	460.4	460.9	461.3	461.8	462.1	462.6	463.0	463.5	463.9	464.3	464.7	465.2	465.6
81	460.3	460.7	461.2	461.6	461.9	462.4	462.9	463.3	463.8	464.2	464.7	465.0	465.5	465.9	466.4	466.8	467.2	467 6	468 1	468.5
82	463.1	463.5	463.9	464.4	464.8	465.2	465.7	466.1	466.6	467.1	467.5	467.9	468.3	468.8	469.2	469 7	470.0	470.5	470.9	471.4
83	465.9	466.3	466.8	467.2	467.6	468.1	468.5	468.9	469.4	469.9	470.3	470.7	471.2	471.6	472.1	472.5	472.9	473.4	473.8	474.3
84	468.7	469.2	469.6	470.1	470.4	470.9	471.4	471.8	472.3	472.7	473.2	473.6	474.0	474.5	474.9	475.4	475.8	476.2	476.7	477.1
85	471.5	471.9	472.4	472.9	473.3	473.7	474.2	474.6	475.1	475.6	476.0	476.4	476.9	477.3	477.8	478.2	478.6	479.1	479.5	479.9
86	474.3	474.7	475.2	475.7	476 0	476.5	476.9	477.4	477.9	478.3	478.8	479.2	479.6	480.1	480.6	481.0	481.4	481.9	482.3	482.8
87	476.9	477.4	477.9	478.4	478.7	479.2	479.7	480.1	480 6	481.1	481.5	481.9	482.4	482.9	483.3	483.8	484.2	484.6	485.1	485.6
88	479.7	480.2	480.7	481.1	481.5	482.0	482.5	482.9	483.4	483.9	484.3	484.7	485.2	485.6	486.1	486.6	486.9	487.4	487.9	488.4
89	482.4	482.9	483.4	483.9	484.2	484.7	485.2	485.7	486.1	486.6	487.1	487.4	487.9	488.4	488.9	489.3	489.7	490.2	490.7	491.1
90	485.2	485.6	486.1	486.6	486.9	487.4	487.9	488.4	488.9	489.3	489.8	490.2	490.7	491.1	491.6	492.1	492.5	492.9	493.4	493.9
91	487.8	488.3	488.8	489.3	489.6	490.1	490.6	491.1	491.5	492.0	492.5	492.9	493.4	493.8	494.3	494.7	495.2	495.6	496.1	496.6
92	490.5	491.0	491.5	491.9	492.4	492.8	493 3	493.8	494.3	494.8	495.2	495.6	496.1	496.6	497.1	497.5	497.9	498.4	498.9	499.4
93	493.2	493.7	494.2	494.6	495.0	495.5	496.0	496.5	496.9	497.4	497.9	498.3	498.8	499.3	499.7	500.2	500.6	501.1	501.6	502.1
94	495.8	496.3	496.8	497.2	497.6	498.1	498.6	499.1	499.6	500.1	500.5	500.9	501.4	501.9	502.4	502.9	503.3	503.7	504.2	504.7
95	498.5	498.9	499.4	499.9	500.3	500.8	501.3	501.8	502.3	502.7	503.2	503.6	504.1	504.6	505.1	505.6	506 0	506.4	506.9	507.4
96	501.1	501.6	502.0	502.5	502 9	503.4	503.9	504.4	504.9	505.4	505.9	506.3	506.7	507.2	507.7	508.2	508.6	509.1	509.6	510.1
97	503.7	504.2	504.7	505.2	505.6	506.0	506.5	507.0	507 5	508.0	508.5	508.9	509 4	509.9	510.4	510.9	511.3	511 7	512.2	512.7
98	506.2	506.7	507 2	507.7	508.1	508.6	509.1	509.6	510 1	510.6	511.1	511.5	511.9	512.5	512.9	513.5	513.9	514.3	514.8	515.3
99	508.8	509.3	509.8	510.3	510.7	511.2	511 7	512.2	512.7	513.2	513.7	514.1	514.6	515.1	515.6	516.1	516.5	517.0	517.5	518.0
100	511.4	511.9	512.4	512.9	513.3	513.8	514.3	514.8	515.3	515.8	516.3	516.7	517.2	517.7	518.2	518.7	519.1	519.6	520.1	520.6

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.
Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.
Table has been condensed to serve field men in approximating meter readings. Intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

More inside information on POWELL VALVES

This small size 200-pound "White Star" Bronze Gate Valve looks very much like the same type of valve in other makes. But back of it—back of every Powell Valve—is nearly a century of specializing in the manufacture of Dependable valves for Industry.

The result of this Powell "know how" is a line of valves ruggedly built to give long, uninterrupted service and require minimum maintenance. These are reasons why Powell Valves are the choice of leading industrial plants throughout the nation.

The complete Powell Line includes all types of valves (Globes, Angles, Gates, Checks, Y's, etc.) not only in bronze, iron and steel but also in a wide variety of pure metals and special alloys to meet every requirement for corrosion resistance (Catalogs on request).

And if you have any unusual flow control problems, Powell Engineers will be glad to make a careful study of your requirements and design special valves to meet the conditions.

The Wm. Powell Co.

Dependable Valves Since 1846

Cincinnati 22, Ohio

This valve, especially adapted for steam, oil, water or gas lines is widely used in the Nation's leading refineries.

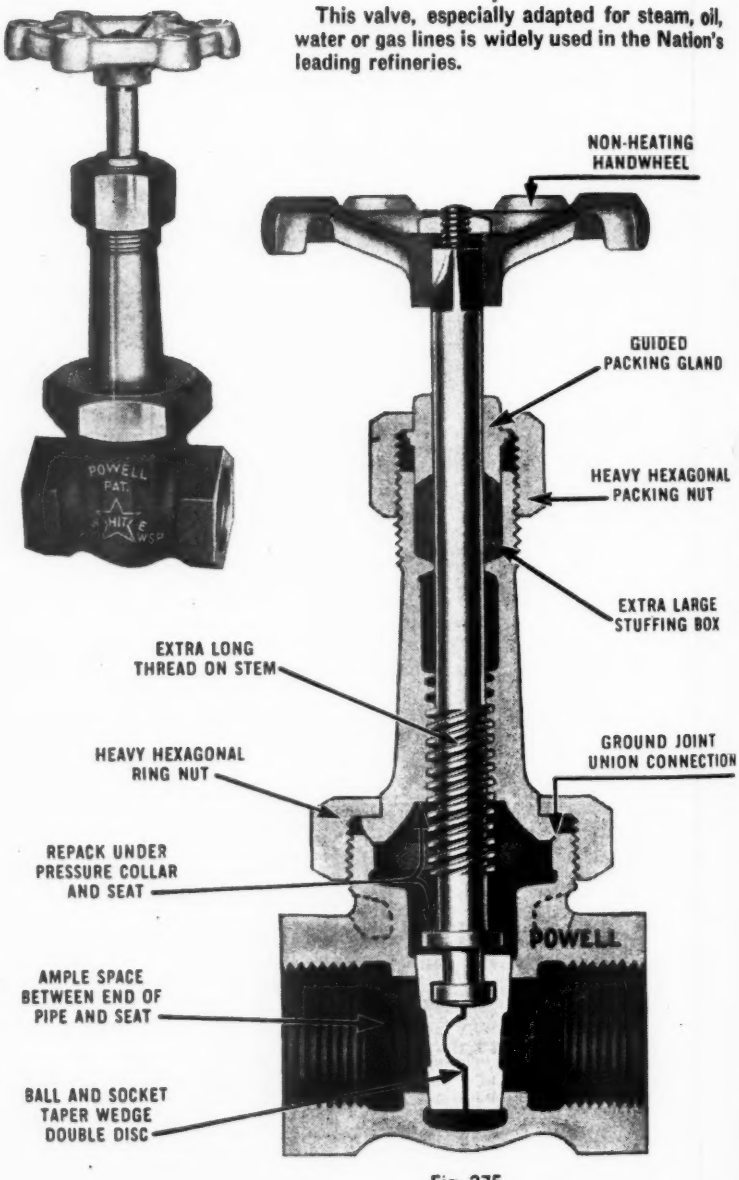

NON-HEATING HANDWHEEL
GUIDED PACKING GLAND
HEAVY HEXAGONAL PACKING NUT
EXTRA LARGE STUFFING BOX
EXTRA LONG THREAD ON STEM
GROUND JOINT UNION CONNECTION
HEAVY HEXAGONAL RING NUT
REPACK UNDER PRESSURE COLLAR AND SEAT
AMPLE SPACE BETWEEN END OF PIPE AND SEAT
BALL AND SOCKET TAPER WEDGE DOUBLE DISC
POWELL
POWELL PAT.

Fig. 375
BRONZE "WHITE STAR" GATE VALVE

POWELL VALVES

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

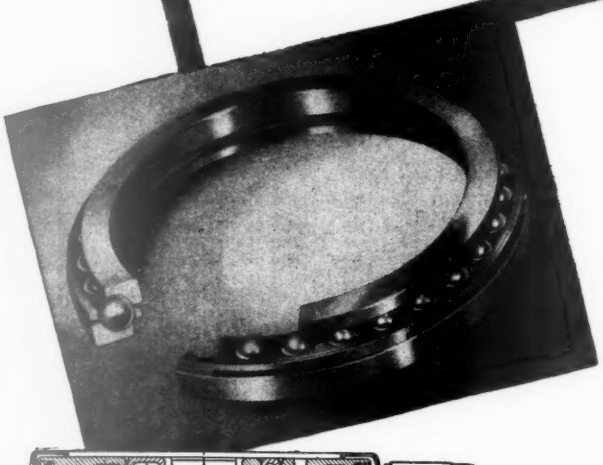
Static Press. 2700-2795-lb.

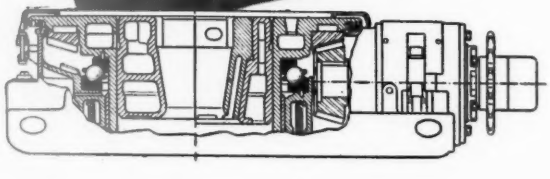
Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	2700	2705	2710	2715	2720	2725	2730	2735	2740	2745	2750	2755	2760	2765	2770	2775	2780	2785	2790	2795
2	73.68	73.74	73.81	73.88	73.95	74.02	74.08	74.15	74.22	74.29	74.35	74.42	74.49	74.56	74.62	74.69	74.76	74.83	74.89	74.96
4	104.2	104.3	104.4	104.5	104.6	104.7	104.8	104.9	105.0	105.1	105.2	105.3	105.4	105.5	105.5	105.6	105.7	105.8	105.9	106.0
6	127.7	127.8	127.9	128.0	128.1	128.3	128.4	128.5	128.6	128.7	128.8	128.9	129.1	129.2	129.3	129.4	129.5	129.6	129.7	129.9
8	147.4	147.5	147.7	147.8	147.9	148.1	148.2	148.3	148.5	148.6	148.7	148.9	149.0	149.2	149.3	149.4	149.6	149.7	149.8	149.9
10	164.8	164.9	165.1	165.2	165.4	165.5	165.7	165.8	165.9	166.1	166.3	166.4	166.6	166.7	166.9	167.0	167.2	167.3	167.5	167.7
12	180.5	180.6	180.8	181.0	181.2	181.3	181.5	181.6	181.8	182.0	182.1	182.3	182.5	182.7	182.8	182.9	183.1	183.3	183.4	183.6
14	195.0	195.1	195.3	195.5	195.7	195.9	196.0	196.2	196.4	196.6	196.7	196.9	197.1	197.3	197.5	197.6	197.8	198.0	198.2	198.4
16	208.4	208.6	208.8	209.0	209.2	209.4	209.6	209.8	209.9	210.2	210.3	210.5	210.7	210.9	211.1	211.3	211.5	211.7	211.8	212.0
18	221.1	221.3	221.5	221.7	221.9	222.1	222.3	222.5	222.7	222.9	223.1	223.3	223.5	223.7	223.9	224.1	224.3	224.5	224.7	224.9
20	233.0	233.2	233.4	233.7	233.9	234.1	234.3	234.5	234.7	234.9	235.1	235.4	235.6	235.8	236.0	236.2	236.4	236.7	236.9	237.1
21	238.8	239.0	329.2	239.5	239.7	239.9	240.1	240.3	240.6	240.8	241.0	241.2	241.4	241.6	241.8	242.1	242.3	242.5	242.7	242.9
22	244.4	244.6	244.8	245.0	245.3	245.5	245.7	245.9	246.2	246.4	246.6	246.8	247.1	247.3	247.5	247.7	247.9	248.2	248.4	248.6
23	249.9	250.1	250.3	250.6	250.8	251.1	251.3	251.5	251.7	251.9	252.2	252.4	252.6	252.9	253.1	253.3	253.6	253.8	254.0	254.2
24	255.3	255.5	255.7	255.9	256.2	256.5	256.7	256.9	257.1	257.4	257.6	257.8	258.1	258.3	258.5	258.8	259.0	259.3	259.5	259.7
25	260.5	260.7	261.0	261.2	261.5	261.7	261.9	262.2	262.4	262.7	262.9	263.1	263.4	263.6	263.8	264.1	264.3	264.6	264.8	265.0
26	265.7	265.9	266.2	266.4	266.7	266.9	267.1	267.4	267.6	267.9	268.1	268.4	268.6	268.9	269.1	269.3	269.6	269.8	270.0	270.3
27	270.8	271.0	271.2	271.5	271.7	272.0	272.2	272.5	272.7	273.0	273.2	273.5	273.7	273.9	274.2	274.4	274.7	274.9	275.2	275.4
28	275.8	276.0	276.2	276.5	276.8	277.0	277.2	277.5	277.8	278.0	278.2	278.5	278.8	279.0	279.3	279.5	279.8	280.0	280.3	280.5
29	280.6	280.8	281.1	281.4	281.6	281.9	282.1	282.4	282.7	282.9	283.1	283.4	283.7	283.9	284.2	284.4	284.7	284.9	285.2	285.5
30	285.4	285.6	285.9	286.2	286.4	286.7	286.9	287.2	287.5	287.8	288.0	288.2	288.5	288.8	289.0	289.3	289.6	289.8	290.1	290.3
31	290.1	290.4	290.6	290.9	291.2	291.5	291.7	291.9	292.3	292.5	292.8	293.0	293.3	293.6	293.8	294.1	294.4	294.7	294.9	295.2
32	294.8	295.0	295.3	295.6	295.9	296.1	296.4	296.6	296.9	297.2	297.4	297.7	298.0	298.3	298.5	298.8	299.1	299.4	299.6	299.9
33	299.4	299.6	299.9	300.2	300.5	300.7	301.0	301.3	301.6	301.8	302.1	302.4	302.6	302.9	303.2	303.4	303.7	304.0	304.3	304.5
34	303.8	304.1	304.4	304.7	304.9	305.2	305.5	305.8	306.1	306.4	306.6	306.9	307.2	307.5	307.7	308.0	308.3	308.6	308.8	309.1
35	308.3	308.5	308.8	309.1	309.4	309.7	309.9	310.2	310.5	310.8	311.1	311.4	311.6	311.9	312.2	312.5	312.8	313.1	313.3	313.6
36	312.7	312.9	313.2	313.5	313.8	314.1	314.3	314.6	314.9	315.2	315.5	315.8	316.1	316.4	316.6	316.9	317.2	317.5	317.8	318.1
37	316.9	317.2	317.5	317.8	318.1	318.4	318.7	319.0	319.3	319.6	319.8	320.1	320.4	320.7	321.0	321.3	321.6	321.9	322.2	322.5
38	321.2	321.5	321.8	322.1	322.4	322.7	322.9	323.2	323.5	323.9	324.1	324.4	324.7	325.0	325.3	325.6	325.9	326.2	326.4	326.7
39	325.4	325.7	326.0	326.3	326.6	326.9	327.2	327.5	327.8	328.1	328.4	328.7	328.9	329.3	329.5	329.9	330.2	330.5	330.7	331.0
40	329.6	329.8	330.2	330.5	330.8	331.1	331.4	331.7	332.0	332.3	332.6	332.9	333.2	333.5	333.8	334.1	334.4	334.7	335.0	335.3
41	333.7	333.9	334.2	334.6	334.9	335.2	335.4	335.8	336.1	336.4	336.7	337.0	337.3	337.6	337.9	338.2	338.5	338.8	339.1	339.4
42	337.7	337.9	338.2	338.6	339.0	339.3	339.5	339.9	340.2	340.5	340.8	341.1	341.4	341.7	342.0	342.3	342.6	342.9	343.2	343.6
43	341.7	341.9	342.3	342.6	342.9	343.3	343.5	343.8	344.2	344.5	344.8	345.1	345.4	345.7	346.0	346.3	346.7	347.0	347.3	347.6
44	345.6	345.9	346.2	346.6	346.9	347.2	347.5	347.8	348.2	348.5	348.8	349.1	349.4	349.7	350.0	350.4	350.7	351.0	351.3	351.6
45	349.5	349.8	350.2	350.5	350.8	351.2	351.4	351.8	352.1	352.4	352.7	353.0	353.4	353.7	353.9	354.3	354.6	354.9	355.3	355.6
46	353.4	353.7	354.0	354.4	354.7	355.0	355.3	355.6	355.9	356.3	356.6	356.9	357.3	357.6	357.9	358.2	358.6	358.9	359.2	359.5
47	357.3	357.5	357.9	358.2	358.6	358.9	359.2	359.5	359.9	360.2	360.5	360.8	361.2	361.5	361.8	362.1	362.5	362.8	363.1	363.4
48	361.0	361.3	361.6	361.9	362.3	362.7	363.0	363.3	363.6	364.0	364.3	364.6	364.9	365.3	365.6	365.9	366.3	366.6	366.9	367.2
49	364.8	365.0	365.4	365.7	366.1	366.4	366.7	367.1	367.4	367.8	368.1	368.4	368.8	369.1	369.4	369.7	370.1	370.4	370.7	371.1
50	368.5	368.7	369.1	369.5	369.8	370.2	370.4	370.8	371.2	371.5	371.8	372.1	372.5	372.8	373.1	373.5	373.8	374.2	374.5	374.8
51	372.1	372.4	372.8	373.1	373.5	373.8	374.1	374.5	374.8	375.2	375.5	375.8	376.2	376.5	376.8	377.2	377.5	377.9	378.2	378.5
52	375.8	376.0	376.4	376.8	377.1	377.5	377.8	378.1	378.5	378.9	379.1	379.5	379.9	380.2	380.5	380.9	381.2	381.6	381.9	382.3
53	379.3	379.6	380.0	380.4	380.7	381.1	381.4	381.8	382.1	382.5	382.8	383.1	383.5	383.9	384.2	384.5	384.9	385.3	385.6	385.9
54	382.9	383.2	383.6	383.9	384.3	384.7	384.9	385.3	385.7	386.1	386.4	386.7	387.1	387.5	387.7	388.1	388.5	388.9	389.1	389.5
55	386.4	386.7	387.1	387.5	387.9	388.2	388.5	388.9	389.3	389.6	398.9	390.3	390.7	391.0	391.3	391.7	392.1	392.4	392.7	393.1
56	389.9	390.2	390.6	391.0	391.4	391.7	392.0	392.4	392.8	383.2	393.5	393.8	394.2	394.6	394.9	395.2	395.6	396.0	396.3	396.7
57	393.4	393.7	394.1	394.5	394.9	395.2	395.5	395.9	396.3	396.7	397.0	397.4	397.7	398.1	398.4	398.8	399.2	399.5	399.8	400.2
58	396.9	397.2	397.6	397.9	398.3	398.7	399.0	399.4	399.8	400.1	400.4	400.8	401.2	401.6	401.9	402.3	402.7	403.0	403.3	403.7
59	400.3	400.6	400.9	401.3	401.7	402.1	402.4	402.8	403.2	403.6	403.9	404.2	404.6	405.0	405.3	405.7	406.1	406.5	406.8	407.2
60	403.6	403.9	404.3	404.7	405.1	405.5	405.8	406.2	406.6	406.9	407.3	407.7	408.1	408.4	408.8	409.1	409.5	409.9	410.2	410.6
61	406.9	407.3	407.7	408.1	408.5	408.8	409.2	409.6	409.9	410.3	410.6	411.0	411.4	411.8	412.1	412.5	412.9	413.3	413.6	414.0
62	410.3	410.6	411.0	411.4	411.8	412.2	412.5	412.9	413.3	413.7	414.0	414.4	414.8	415.2	415.5	415.9	416.3	416.7	417.0	417.4
63	413.6	413.9	414.3	414.7	415.1	415.5	415.8	416.2	416.6	417.0	417.3	417.7	418.1	418.5	418.8	419.1	419.6	420.0	420.3	420.7
64	416.9	417.2	417.6	418.0	418.4	418.8	419.1	419.5	419.9	420.3	420.6	421.0	421.4	421.8	422.2	422.6	423.0	423.4	423.7	424.1
65	420.1	420.4	420.8	421.2	421.6	422.0	422.4	422.8	423.2	423.6	423.9	424.3	424.7	425.1	425.4	425.8	426.2	426.6	427.0	427.4
66	423.3	423.7	424.1	424.5	424.9	425.3	425.6	426.0	426.4	426.8	427.2	427.6	428.0	428.4	428.7	429.1	429.5	429.9	430.2	430.6
67	426.5	426.8	427.3	427.7	428.1	428.5	428.8	429.2	429.6	403.0	430.4	430.9	431.2	431.6	431.9	432.3	432.7	433.1	433.5	433.9
68	429.7	430.0	430.4	430.8	431.3	431.7	432.0	432.4	432.8	433.2	433.6	433.9	434.4	434.8	435.1	435.5	435.9	436.4	436.7	437.1
69	432.9	433.2	433.6	434.0	434.5	434.9	435.2	435.6	436.0	436.4	436.8	437.2	437.6	438.0	438.4	438.8	439.2	439.6	439.9	440.3
70	436.0	436.3	436.8	437.2	437.7	438.0	438.3	438.8	439.2	439.6	439.9	440.4	440.8	441.2	441.5	441.9	442.4	442.8	443.1	443.5
71	439.1	439.4	439.8	440.3	440.7	441.1	441.4	441.9	442.3	442.7	443.0	443.5	443.9	444.3	444.6	445.1	445.5	445.9	446.2	446.7
72	442.1	442.5	442.9	443.3	443.8	444.2	444.5	444.9	445.4	445.8	446.1	446.6	446.9	447.4	447.7	448.2	448.6	449.0	449.4	449.8
73	445.2	445.6	446.0	446.4	446.8	447.3	447.6	448.0	448.5	448.9	449.2	449.7	450.1	450.5	450.9	451.3	451.7	452.1	452.5	452.9
74	448.2	448.6	449.0	449.4	449.9	450.3	450.7	451.1	451.5	451.9	452.3	452.7	453.1	453.6	453.9	454.4	454.8	455.2	455.6	455.9
75	451.3	451.6	452.0	452.5	452.9	453.3	453.7	454.1	454.6	455.0	455.3	455.8	456.2	456.6	456.9	457.4	457.8	458.2	458.6	459.1
76	454.3	454.6	455.1	455.5	455.9	456.4	456.7	457.2	457.6	458.0	458.4	458.8	459.3	459.7	460.0	460.5	460.9	461.4	461.7	462.1
77	457.3	457.6	458.1	458.5	458.9	459.4	459.7	460.2	460.6	461.0	461.4	461.8	462.3	462.7	463.1	463.5	463.9	464.4	464.7	465.2
78	460.2	460.6	461.0	461.5	461.9	462.4	462.7	463.1	463.6	464.0	464.4	464.8	465.3	465.7	466.1	466.5	466.9	467.4	467.7	468.2
79	463.1	463.5	463.9	464.4	464.8	465.3	465.6	466.1	466.5	466.9	467.3	467.8	468.2	468.7	469.0	469.5	469.9	470.3	470.7	471.1
80	466.1	466.4	466.9	467.3	467.8	468.2	468.6	469.0	469.5	469.9	470.3	470.7	471.2	471.6	471.9	472.4	472.9	473.3	473.7	474.1
81	468.9	469.3	469.8	470.2	470.7	471.1	471.5	471.9	472.4	472.9	473.2	473.7	474.1	474.6	474.9	475.4	475.8	476.3	476.6	477.1
82	471.9	472.2	472.7	473.1	473.6	474.0	474.4	474.8	475.3	475.7	476.1	476.6	477.0	477.5	477.8	478.3	478.7	479.2	479.5	480.0
83	474.7	475.1	475.5	476.0	476.4	476.9	477.3	477.7	478.2	478.6	479.0	479.5	479.9	480.4	480.7	481.2	481.6	482.1	482.5	482.9
84	477.6	477.9	478.4	478.9	479.3	479.8	480.1	480.6	481.1	481.5	481.9	482.3	482.8	483.3	483.6	484.1	484.5	485.0	485.4	485.8
85	480.4	480.8	481.3	481.7	482.2	482.7	483.0	483.5	483.9	484.4	484.8	485.2	485.7	486.2	486.5	487.0	487.5	487.9	488.3	488.7
86	483.3	483.6	484.1	484.6	485.0	485.5	485.9	486.3	486.8	487.3	487.6	488.1	488.5	489.0	489.4	489.8	490.3	490.8	491.1	491.6
87	486.0	486.4	486.9	487.3	487.8	488.3	488.6	489.1	489.6	490.0	490.4	490.9	491.3	491.8	492.2	492.6	493.1	493.6	493.9	494.4
88	488.8	489.2	489.7	490.2	490.6	491.1	491.5	491.9	492.4	492.9	493.2	493.7	494.2	494.7	495.0	495.5	495.9	496.4	496.8	497.3
89	491.6	491.9	492.4	492.9	493.4	493.9	494.2	494.7	495.2	495.7	496.0	496.5	496.9	497.4	497.8	498.3	498.8	499.2	499.6	500.1
90	494.4	494.7	495.2	495.7	496.2	496.6	497.0	497.5	497.9	498.4	498.8	499.3	499.8	500.2	500.6	501.1	501.6	502.0	502.4	502.9
91	497.1	497.5	497.9	498.4	498.9	499.4	499.7	500.2	500.7	501.2	501.6	502.0	502.5	502.9	503.4	503.8	504.3	504.8	505.2	505.7
92	499.8	500.2	500.7	501.2	501.7	502.1	502.5	503.0	503.5	503.9	504.3	504.8	505.3	505.8	506.2	506.6	507.1	507.6	507.9	508.5
93	502.5	502.9	503.4	503.9	504.4	504.9	505.2	505.7	506.2	506.7	507.1	507.6	508.0	508.5	508.9	509.4	509.9	510.4	510.7	511.2
94	505.2	505.6	506.1	596.6	507.0	507.5	507.9	508.4	508.9	509.4	509.8	510.2	510.7	511.2	511.6	512.1	512.6	513.1	513.4	513.9
95	507.9	508.3	508.8	509.3	509.8	510.3	510.6	511.1	511.6	512.1	512.5	512.9	513.5	513.9	514.3	514.8	515.3	515.8	516.2	516.7
96	510.6	511.0	511.5	511.9	512.4	512.9	513.3	513.8	514.3	514.8	515.2	515.7	516.2	516.6	517.0	517.5	518.0	518.5	518.9	519.4
97	513.2	513.6	514.1	514.6	515.1	515.6	516.0	516.5	516.9	517.5	517.9	518.3	518.8	519.3	519.7	520.2	520.7	521.2	521.6	522.1
98	515.8	516.2	516.7	517.2	517.7	518.2	518.6	519.1	519.6	520.1	520.5	521.0	521.5	521.9	522.4	522.9	523.4	523.9	524.2	524.7
99	518.5	518.9	519.4	519.9	520.4	520.9	521.3	521.8	522.3	522.8	523.2	523.7	524.2	524.7	525.1	525.6	526.1	526.5	526.9	527.4
100	521.1	521.5	522.0	522.5	523.0	523.5	523.9	524.4	524.9	525.4	525.8	526.3	526.8	527.3	527.7	528.2	528.7	529.2	529.6	530.1

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.
Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.
Table has been condensed to serve field men in approximating meter readings. Intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

HIGHER ROTARY SPEEDS

WITH TORRINGTON ANGULAR CONTACT BEARINGS





Designed to take both the radial and thrust loads imposed by the high speed operation of rotary tables, Torrington Angular Contact Bearings are used in a large majority of equipment of this type. Engineered to meet this particular application, the bearings are rigidly controlled in the hardening and grinding process to insure precision and equalized load distribution under all service conditions. Because of their excellent anti-friction characteristics and their high load capacity, faster drilling speeds and deeper drilling are possible.

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TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

Running Tour WITH MEN IN THE INDUSTRY

John R. Suman, Houston, Texas, has been elected a vice president and director of Standard Oil Company (New Jersey), according to Eugene Holman, company president. Suman assumed his new duties on February 1, leaving his position as vice president and director of Humble Oil and Refining Company, affiliate of Jersey Standard, to take the new post. **Wallace E. Pratt** has resigned as a vice president of Standard. He has been associated with Humble and Standard for nearly 30 years and will continue as a director and member of the executive committee of the company.

John R. Suman
—Washington Press Photo.

Suman became a director of the Humble organization in 1927 and was made vice president in charge of production in 1933. He is a director and former president of the American Institute of Mining and Metallurgical Engineers, from which he received the Lucas medal in 1943. His book "Petroleum Production Methods" has long been a standard reference work. Pratt, one of the country's most widely known petroleum geologists and executives, has been identified with the finding and development of oil resources in many parts of the world. He is author of "Oil in the Earth."

A. J. Donnelly has been elected to the board of directors of General Petroleum Corporation, according to S. J. Dickey, president. In addition to his duties as a director, Donnelly will retain the post he now holds as manager of industrial relations for the company. He started with General Petroleum as a salesman in Seattle in 1924, and has held various executive assignments in Portland, Oakland, San Francisco, and Los Angeles. Prior to moving to Los Angeles last year, Donnelly was stationed for 10 years in San Francisco as the company's northern California manager.

J. T. Cropper has been appointed warehouse manager of the Houston branch warehouse of E. H. Edwards Company, situated at 1208 Velasco, Houston.

O. W. (Oil Well) Jones, commercial and industrial manager of the Central Power and Light Company of Corpus Christi, Texas, and a member of the board of directors of the Petroleum Electric Power Association, is recovering from a major operation and reported to be getting along nicely.

Ivan F. Harlow has been appointed production manager for the inorganic division of The Dow Chemical Company according to Dr. Willard H. Dow, president of the company. Harlow assumed managerial duties formerly performed by **Dr. E. O. Barstow** who has been elected a vice president of the company and has taken on increased executive responsibilities. Harlow has been in direct charge of the development and production of bromine and bromine compounds almost since his affiliation with the company in 1909. He is also vice president and general manager of the Ethyl-Dow Chemical Company, a Dow subsidiary engaged in the extraction of bromine from sea water at Wilmington, North Carolina, and Freeport, Texas. Dr. Barstow joined the company three years after its incorporation in 1897. He became a director in 1931 and vice president in 1941. He is also director of the Ethyl-Dow Chemical Company, the Dow Magnesium Corporation and the Midland Ammonia Company.

John D. Collins, director in charge of District 1, PAW and a vice president of Tide Water Associated Oil Company, died at his residence, 53 Henhawk Road, Great Neck, Long Island, shortly after noon on January 20 following a heart attack earlier in the week. He was 52 years old. Collins had been an employe and an official of Tide Water and its predecessor, Tide Water Oil Company, for nearly 24 years. He served in numerous executive capacities before being appointed a vice president on December 17, 1936. He was granted a leave of absence on June 5, 1944, to serve as director in charge of District 1, PAW. Collins was a native of New York City, was educated there, and graduated from Pace Institute.

Roger Sherman, geologist for the Creole Petroleum Company, arrived in Miami from Caracas on January 26. He was en route to New York to confer with company officials and plans to be in this country for about two months after which he will return to Venezuela. He has been with Creole for 11 years.

Robert E. Bockrath has been appointed manager of the magnesium sales for Dow Chemical Company's Houston, Texas, office. In the interest of the expanding activities of the magnesium division, Bockrath assumed his new duties on February 1. He will operate under the jurisdiction of **Arthur Smith, Jr.,** southwestern sales manager of the magnesium division, headquarters in St. Louis, Missouri. A graduate mechanical engineer of the University of Michigan, Bockrath entered the employ of Dow in 1934 and has been with the magnesium division since January, 1939, in research, engineering and sales development.

R. E. Bockrath

C. L. Rynd has accepted an assignment with The Texas Company (Venezuela), Ltd. He expects to leave for the Eastern Venezuela fields soon. Rynd was formerly with the same company and has been in the California industry for the last 2 years.

C. H. Strickland has accepted an assignment in the drilling and producing division of the Standard Oil Company of Egypt. He was formerly with the Iraq Petroleum Company, Ltd., in the Kirkuk-Mosul area.

John H. Sybrandt, for many years manager of the Chicago office of the Ludlow Valve Manufacturing Company, Inc., has retired.

Lowell E. Senet, an engineer with long experience in valve applications, has been appointed to the managership. He is a graduate of the Case School of Applied Science and has previously been employed with the engineering departments of the Grinnell and Crane companies.

Lowell E. Senet
—Gibson Studios, Chicago.

L. A. "Frenchie" Thomas, well known to many oil men in foreign operating areas, arrived in California in December. He has served in the foreign operating end of the oil industry in Iran, Venezuela and Trinidad, British West Indies, for a number of years, ran an oil well cementing service in Trinidad and recently has been engaged in contracting rehabilitation work of oil wells in that British colony. He also has other interests in the petroleum industry of Trinidad.

L. W. Wiedey, assistant manager of Tropical Oil Company at Bogota, Colombia, accompanied by Mrs. Wiedey, left for Bogota on January 3.

Benjamin F. Zwick, manager of International Ecuadorean Petroleum Company, Guayaquil, Ecuador, accompanied by Mrs. Zwick, were visitors in California in January. Zwick combined a business mission with a chance to meet friends from the California oil industry and to inspect drilling and development operations. Zwick's business will take him to Houston, Texas, and Toronto, Canada, prior to his returning to Guayaquil.

Starr Thayer, consulting engineer, Houston, Texas, has moved his offices from the Rusk Building to 318 Southern Standard Building, 711 Main Street.

J. W. Cason, former chief accountant of the Standard Oil Company of Louisiana, has been appointed comptroller of Interstate Oil Pipe Line Company, new organization formed recently with the consolidation of the Louisiana com-

pany and Oklahoma Pipe Line Company. Other appointments to Interstate positions, as announced by L. F. Kahle, executive vice president of the company, include: P. H. Hunter, former chief tax accountant for Louisiana, as secretary in charge of all legal and tax matters; H. P. Hellinghausen, as treasurer, continuing in that capacity, and W. B. Fulton, for 25 years chief engineer for the Louisiana company's pipe line department, as chief engineer for Interstate.

▸ **J. A. "Jimmy" Wirtensohn,** in charge of drilling operations for Cia. de Petroleo Shell de Colombia, arrived in California recently on business. He is renewing acquaintances with his friends in this country before returning to his duties in Colombia.

▸ **Dr. John F. Dodge,** faculty of the University of Southern California, recently returned from an extended visit in Venezuela. He was engaged in consultation work in connection with oil field exploration there.

▸ **D. L. Adams** has accepted an assignment with Socony-Vacuum Oil Company, Venezuela. He recently returned from Egypt and expects to proceed to the fields of Venezuela at an early date. He will be engaged in exploration and development work for his principals in that country.

▸ **R. P. Borncamp** has accepted a position with the Compania Consolidada de Petroleo, Eastern Venezuela. He has been engaged in foreign oil field development in the past in various countries—Trinidad, British West Indies, Burma, and many years ago was with the Sinclair interests in Angola, Portuguese, West Africa.

▸ **James Thompson,** formerly with the Burmah Oil Company, Ltd. (India), has accepted an assignment in the exploration division of Socony-Vacuum Oil Company in Venezuela. He will leave to assume his new duties soon.

▸ **Philip G. Wharton,** general auditor of the Atlantic Refining Company since 1935, has been elected a vice president of that organization, according to an announcement by Robert H. Colley, president. Wharton has been with the company since 1911 serving for most of that period in the auditing department. In his new position, he will have charge of certain administrative functions. **J. P. Miller, Jr.** has been named general auditor succeeding Wharton.

▸ **Dave A. Dimmit,** formerly with the International Ecuadorean Petroleum Company in Ecuador, has returned to the United States and is visiting his son who is in the armed forces training in Texas.

▸ **R. D. Gerner,** formerly with General Petroleum Corporation in California, drilling and producing division, expects to proceed to the Socony-Vacuum de Colombia. Gerner also was previously employed by Socony-Vacuum in Egypt.

▸ **Hobart Lamar,** recently in charge of drilling operations for the New Zealand Petroleum Company at Gisborne, New Zealand, returned to California in December after being abroad for approximately 6 years. Lamar has served in many other foreign oil producing areas including Venezuela, Colombia, Trinidad and also with the Amiranian Oil Company in the Near East prior to his service in New Zealand.

▸ **H. E. "Swede" Johnson,** with the Drilling and Exploration, Inc., at Bahia, Brazil, arrived in California before the holidays accompanied by Mrs. Johnson. Upon completion of their vacation in California, they expect to return to their former surroundings in Brazil.

▸ **Alex Lae,** drilling and producing division of T. L. L., Pointe-a-Pierre, Trinidad, British West Indies, is spending his vacation in California where he is visiting oil field operations. He expects to return to Trinidad on the completion of his vacation in the United States.

▸ **Paul H. Molidor,** formerly with the Socony-Vacuum de Colombia at Canta Gallo, Magdalena Valley, has been visiting friends and relatives in California. He has accepted a new assignment with the Tropical Oil Company at El Centro, California.

▸ **C. M. MacSoreley,** engineer, Creole Petroleum Corporation, Maracaibo, accompanied by Mrs. MacSoreley, was a visitor in California on his vacation. MacSoreley is engaged in drilling and producing of the marine operations of his company, on Maracaibo Lake. Mr. and Mrs. MacSoreley returned to Venezuela on February 3.

▸ **Dr. F. J. Sanders,** formerly superintendent of the Toledo refinery of Standard Oil Company (Ohio), has been

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It is not always a question of manpower or weather conditions that slows the erection of sectional steel buildings in the field.

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STOP "Leap-Frog" Corrosion

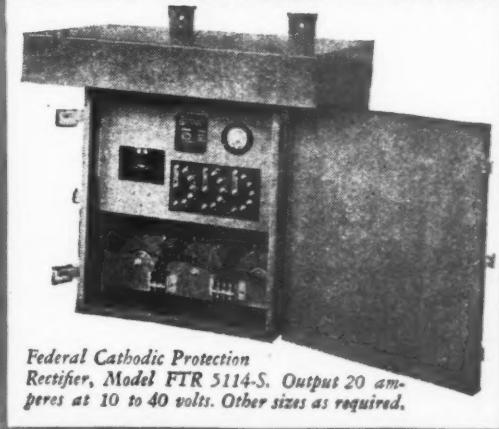
"Leap-Frog" Corrosion damages underground pipes and cables.

Pipes or other metal structures are in places electro-positive in relation to the soil and due to natural galvanic action corrosion results. Metal is taken away from one section of pipe and deposited somewhere else along the exposed pipe.

By using Federal Cathodic Protection Rectifiers, "Leap-Frog" corrosion is foiled. On constant guard is a direct current charge which cancels the harmful electrolytic corrosive action on oil, gas and water pipelines and underground cables.

These Federal units have no moving parts, so they last indefinitely — with the absolute minimum of attention. In desert heat or torrid dampness they keep on the job day and night.

Proper engineering for the corrosion problem at hand calls for the specialized consulting engineering service which is yours — when you look to Federal. Write today for full details.



Federal Cathodic Protection Rectifier, Model FTR 5114-S. Output 20 amperes at 10 to 40 volts. Other sizes as required.

Federal Telephone and Radio Corporation

Newark 1, N. J.

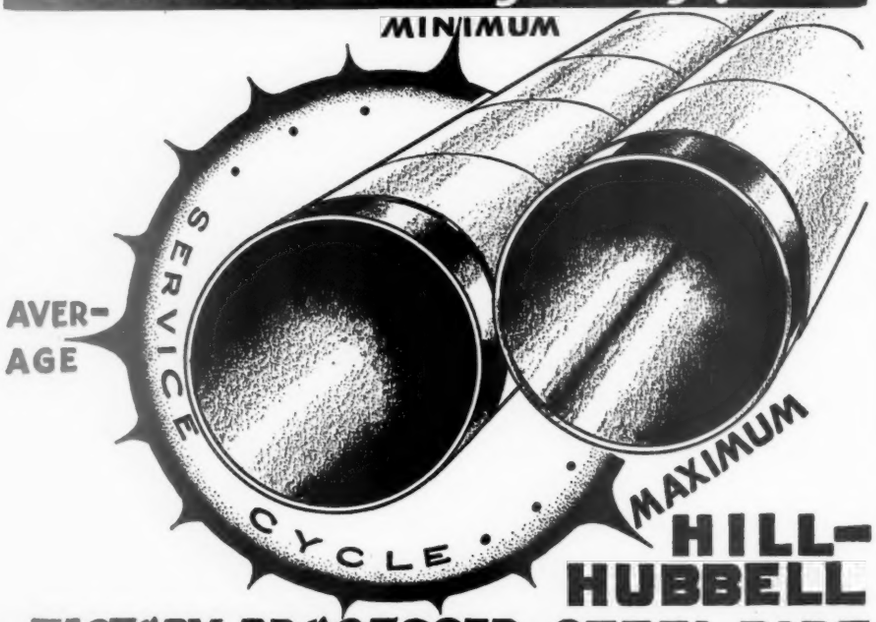
An IT&T Associate

placed in charge of the company's No. 2 refinery in Cleveland, Ohio. He came to Standard Oil in 1934 to organize the technical service group of the manufacturing department's process and development division. He headed technical service until 1939 when he was placed in charge of the Toledo plant.

▸ **L. D. Coady**, formerly with the Atlantic Refining Company, has joined C. W. Murchison and Toddie L. Wynne in the capacity of vice president and chairman of the executive committee of their companies. His offices will be at 40 Highland Park Village, Dallas, Texas. He will be an executive in the following companies: American Liberty Oil, American Liberty Pipe Line, Southport Petroleum of Delaware, Talco Pipe Line, Blue Bird Investment, Talco Asphalt and Refining, and Corpus Rosa Pipe Line.

▸ **Judson Laird** has been appointed assistant to the director of public relations, Sun Oil Company, and will be in charge of public relations at the company's Marcus Hook, Pennsylvania, and Toledo, Ohio, plants. He has been editor of the *Sun News*, Sun Oil Company house publication, since 1938. **William J. Getty, Jr.**, formerly associate editor of the *Sun News*, succeeds Laird as editor. Getty has been with Sun since December, 1926, and on the staff of the magazine since November, 1942.

What Steel Pipe Protection insures Longevity? ..



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FACTORY PROCESSED STEEL PIPE IS YOUR ANSWER!

Engineers think in terms of years of service, when ordering Steel Pipe Protection. Our standard specifications and applications are the answer to their research demands.

HILL-HUBBELL factory processed steel pipe has dominant advantages for longevity of pipe installations.

Our experience and services are at your disposal on any question pertaining to Steel Pipe Protection. We invite your inquiries.

HILL-HUBBELL
- FACTORY APPLIED
- INDOOR PROCESSED
- THERMAL CONTROLLED COATING AND WRAPPING
- WARRANTED LOCATION DELIVERY

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HILL, HUBBELL & CO. · Division · Cleveland, Ohio
· EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. ·

▸ **R. O. Perry** has been appointed senior account executive of the Russell P. Ostrander Advertising Agency, Los Angeles. He formerly was advertising manager of Emsco Derrick and Equipment Company. Perry will supervise many of the agency's oil field equipment accounts, and will be active in the development of new industrial accounts.

R. O. Perry

▸ **D. W. Patton**, formerly with the Colombian Petroleum Company, Cucuta, Colombia, resigned from that company and returned to California recently. He has accepted an assignment with the Tropical Oil Company of Colombia and expects to leave for the field at an early date.

▸ **George B. Davies** of Jensen Petroleum Company has been named president of the Chicago Oil Men's Club for 1945. Other officers are **Henry G. Plane**, Johnson Oil Refining Company, vice president; **M. W. Prellberg**, James B. Berry Sons' Company, secretary, and **R. P. Baker**, Pure Oil Company, treasurer.

▸ **Bruce K. Brown** has been reelected a director of Standard Oil Company of Indiana since resigning his post with PAW. He was first elected to the board in 1940, but resigned in 1942 and was appointed PAW deputy administrator. As an operating executive, Brown again becomes general manager of Standard of Indiana's research and development activities.

▸ **MacLean Houston** of the United Refining Company, Warren, Pennsylvania, has been elected chairman of the technical advisory committee of the Pennsylvania Grade Crude Oil Association. He succeeds **W. A. Johnston** of the Bradford Penn Refining Corporation, Clarendon, Pennsylvania, who resigned the post to accept an assignment with the Attapulgus Clay Company, Philadelphia.

▸ **Peter J. Gaylor** has resigned from the Standard Oil Development Company to open his law offices at 1121 Kinney Building, 790 Broad Street, Newark 2, New Jersey. He will specialize in patent law, trade marks, and copyrights. Gaylor will also publish the *Technical Survey*, a weekly service covering new developments and trends in technology.

▸ **Stafford Park** has returned to his former duties in the Long Beach, California, office of the Eastman Oil Well Survey Corporation. Having served more than 2 years in the navy, Lieutenant Park has seen considerable action in the combat areas.

▸ **Hiram H. Spain**, 54, assistant division superintendent Gulf Coast production of Humble Oil and Refining Company, died at his home in Houston, Texas, recently. Spain started his career in the oil business as a driller for Humble in July, 1916.

Moore WELL SERVICING MAST

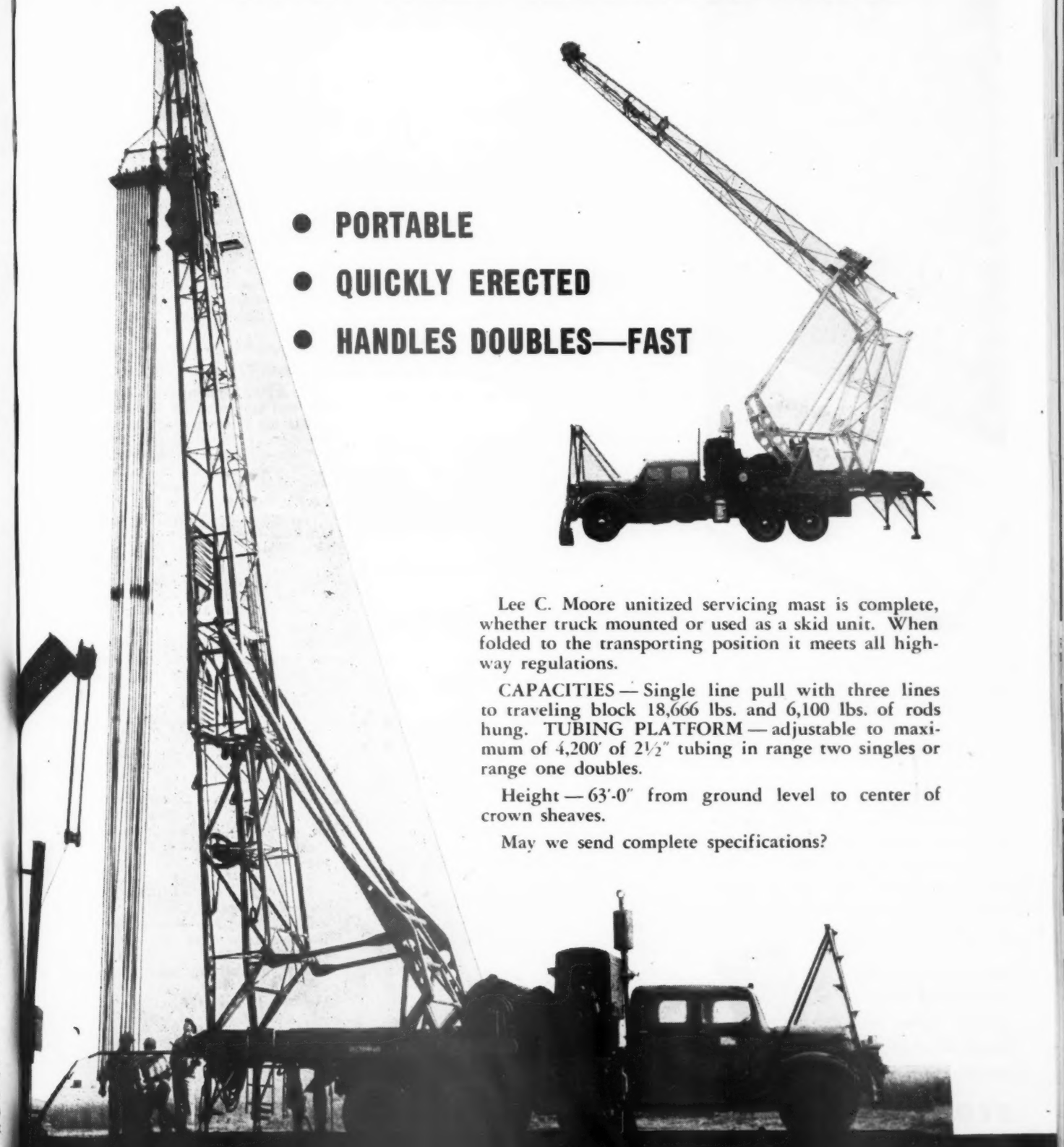
- PORTABLE
- QUICKLY ERECTED
- HANDLES DOUBLES—FAST

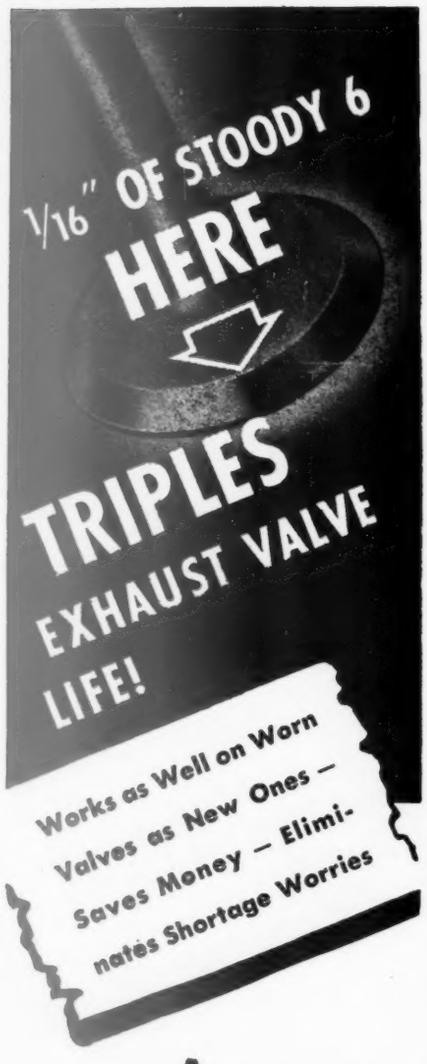
Lee C. Moore unitized servicing mast is complete, whether truck mounted or used as a skid unit. When folded to the transporting position it meets all highway regulations.

CAPACITIES — Single line pull with three lines to traveling block 18,666 lbs. and 6,100 lbs. of rods hung. TUBING PLATFORM — adjustable to maximum of 4,200′ of 2½″ tubing in range two singles or range one doubles.

Height — 63′-0″ from ground level to center of crown sheaves.

May we send complete specifications?




1/16" OF STOODY 6
HERE
TRIPLES
EXHAUST VALVE
LIFE!
Works as Well on Worn Valves as New Ones — Saves Money — Eliminates Shortage Worries

AN ounce or two of Stoody 6 welded to new or worn exhaust valve faces adds 300 to 400 percent to their normal life, prevents burning, saves overhaul jobs, costs only a few cents per valve.

This folder outlines the simple procedure any garage or shop equipped with acetylene welding equipment can follow. Eliminates your worries about valve replacements and saves money as well.

Write for folder "Weld New Life Onto Worn Valves With Stoody 6" — no obligation.

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STOODY 6 · THE METAL THAT ADDS EXTRA MILES TO EXHAUST VALVE LIFE!

LAUGH WITH BARNEY

One young girl to another: "Of course I had to tell her she looked like a million—and I meant every year of it."

"I'm sick of marriage. Tom hasn't kissed me since I came back from my honeymoon."
"Why not divorce him?"
"Huh? Oh, I'm not married to Tom."

"Well, Mary, now that we've struck oil, I want you to have some decent clothes."
"Bill Jones, I've worn decent clothes all my life. Now I'm going to dress like other women."

"What's the matter, Alice?"
"I've got rheumatism in my muscles."
"You ought to visit a masseur."
"What's that?"
"A man who pinches you all over."
"Oh! You mean a marine!"

Jake: I wrote to a farm paper to find out how long cows should be milked.
Jim: What did they say?
Jake: They said milk 'em just like short cows.

"Say, Doc, do you remember last year when you cured my rheumatism? You told me to avoid dampness."
"That's right. What's wrong?"
"Well, can I take a bath now?"

Boss: Rufus, did you go to your lodge meeting last night?
Rufus: No, sah, we done have to postpone it.
Boss: Why was that?
Rufus: De Grand, All-Powerful, Most-Invincible, Supreme Unconquerable Potentate done got beat up.

She was young, fair and pretty,
She's a girl I'll never forget;
We were in a pullman sleeper
When, by accident, we met.
Yes, I always shall remember well,
The girl and time and place;
I was coming from an upper berth
And stepped upon her face.

Rastus (throwing down four aces): There, guess I won this old pot, all right.
Sambo (angrily): You play this game honest, boy; play it honest! I know what cards I dealt you!

It was the first time she had been to dinner with them, and they smiled indulgently as she refused a whisky and soda.
"I've never touched it in my life," she explained.
"Why not try it?" urged her host. "See if you like the taste."
She blushed and shyly consented, and he poured her out a mixture which she delicately raised to her lips.
"Why," she cried, "you've given me Scotch!"

Hubby: Darling, did you take a dollar bill out of my right-hand pants pocket last night?
Wifey: Certainly not. Maybe you don't know it, but there's a hole in that pocket.

When Sue returned from a ride, her Mother noticed that one of her shoes was muddy. "Why is your right shoe muddy and not your left?"
"I changed my mind," replied Sue.

A young soldier dashed madly across the dock towards the ferry. With a frantic leap he spanned the three feet of water and crashed onto the deck. "Whew!" he exclaimed when he had gotten his breath. "I made it after all!"
"Made what?" asked one of the deckhands dubiously. "This boat's just coming in!"

Sign in the powder room at Douglas Aircraft: "Is This Trip Really Necessary?"

And then there's the story about the three bears.
Papa bear opened the door of his cupboard and said in a deep gruff voice, "Who drank my beer?"
Mama bear said in her high squeaky voice, "Who drank my beer?"
Little baby bear went "Hic!"

In a high wind a city girl will grab her hat; the country girl grabs her skirts.

The citizen went to the sugar-rationing board and attested: "My wife has no sugar at all in our house, not an ounce of it."
"Remember, now, you're swearing to this," the chairman of the board warned him. "You've got to tell the truth."
The applicant hesitated and repeated, "Gotta tell the truth, eh?"
"Yes, or you'll go to jail," he was warned.
"In that case I'll tell you the truth. We ain't married."

"I'm sorry I slapped you, I thought you were trying to get my sorority pin."

An old Negro had just paid the last installment on his little homestead. The real estate man congratulated him. "Now, Uncle Joe," he said, "I'll make you a deed to the place."
"Thank ye, sah," said the old man, "but iffen hits jes' de same t' you, I'd ruther you'd give me a mortgage to de place."
"But you don't understand, Uncle Joe," said the kindly realtor. "A deed is what you really want."
"Well," said the old man hesitatingly, "all I knows is dat I owned me a farm one time befo'. I had de deed an' de bank had de mortgage. An' first I knowed, the bank done got de farm."

LA FEMME TERRIBLE
Since dames invaded man's domain
We're slipping fast 'tis very plain.
The right to vote was not enough,
They continue still to steal our stuff.
They've snitched our pants
They tell our jokes,
And now, by-gosh, they get our smokes.
—L. A. Eden, Refinery Supply Company.

Sentry: Who goes there?
Answer: Russian soldier.
Sentry: Pass on, Russian soldier.
Sentry: Who goes there?
Answer: English soldier.
Sentry: Pass on, English soldier.
Sentry: Who goes there?
Answer: Who the hell wants to know?
Sentry: Pass on, American soldier.

A bathing suit is a costume with no hooks on it, but plenty of eyes.

Definition of a Strip Tease artist: A Gal who looks good in everything she takes off.

BAKER ROTARY WALL SCRAPER

The Baker Rotary Wall Scraper provides a safe, efficient means of enlarging the walls of an open hole to a diameter considerably greater than the casing or hole through which tool is run.

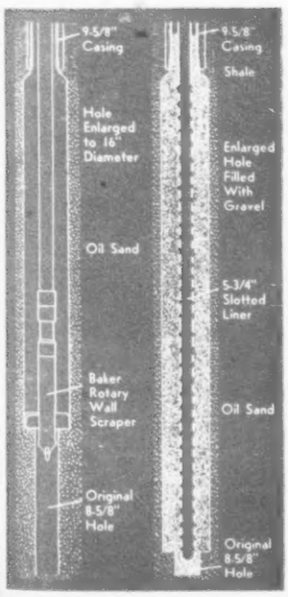
REMARKABLE REAMING CAPACITY

One of the outstanding features of the Baker Rotary Wall Scraper is its remarkable reaming capacity in relation to the O.D. of the tool. It has a maximum expansion on the Cutter Blades ranging from 4" to 36".

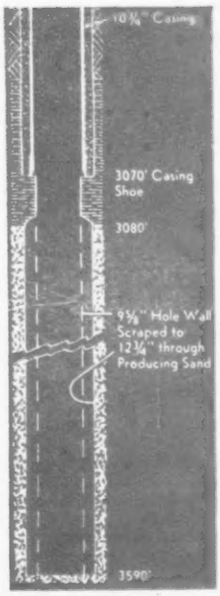
SAFETY

The safety of this tool has been ably demonstrated in thousands of successful runs made in oil fields throughout the world under most adverse operating conditions.

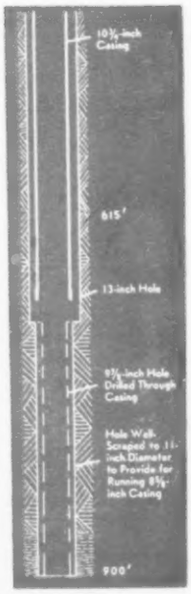
TYPICAL WALL SCRAPER APPLICATIONS



Enlarging hole for gravel packing around liner.



Scraping face of oil sand and enlarging bore for maximum recovery.



Enlarging hole to provide clearance for casing or liners.

Construction Features Which Make Wall Scraper a Sturdy, Dependable Tool

1. Circulation Screen—Design of cone-shaped Screen minimizes abrasive action of fluid and prevents debris from clogging circulation passages.

2. Wall Scraper Body—Machined out of a solid piece of special alloy steel . . . provides great strength.

3. Plunger Head—Provided with oil resistant Seals to prevent fluid by-pass and insure Piston efficiency . . . Blades will positively open.

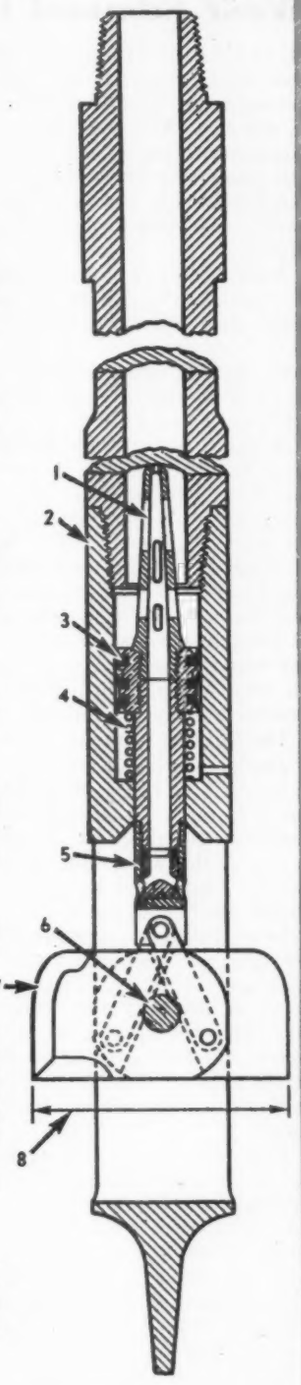
4. Plunger Spring—Strong Plunger Spring insures blades properly closing.

5. Bushing (Circulation Bean)—Fluid is directed on each blade, lubricating and cooling cutting surfaces.

6. Hinge Pin—Machined from solid piece of special alloy steel.

7. Blades—Machined from special alloy steel forgings . . . afford toughness and hardness. Cutting edges are hard-faced and set with Tungsten Carbide inserts. Long bearing surface on blades minimizes "corkscrewing."

8. Blade Expansion—Amazing reaming capacity provided by expansion range of Cutter Blades from 4" to 36".



Competent Baker men will advise, make suggestions, and otherwise assist in securing best possible results.

Send for Baker Broadcast No. 19, giving complete information on the many important field applications for the Baker Wall Scraper.

BAKER OIL TOOLS, INC.

HUNTINGTON PARK - HOUSTON - NEW YORK

West Edmond Crude

VALUABLE additions to the wartime base stocks of aviation gasoline and high grade lubricating oils are being produced in the new West Edmond field, Oklahoma, according to analyses of the crude oils from this field just completed by the Bartlesville (Okla.) Petroleum Experiment Station of the U. S. Bureau of Mines.

Since completion of the discovery well on April 5, 1943, in Oklahoma County, more than 300 other producing wells have been drilled in the West Edmond field, and are yielding about 42,000 bbl. of crude a day. About 100 additional wells are being drilled.

A report from the Bartlesville Experiment Station to Dr. R. R. Sayers, director of the bureau, shows that the crude oils from the two formations underlying the field, when analyzed by the Bureau of Mines Hempel method, yield approximately 31-33 per cent gasoline, 10-11 per cent kerosine, 15-16 per cent gas oil, 19-21 per cent lubricating distillate, and 21 per cent residuum. About 6 per cent of the crudes can be utilized as 91-octane number aviation base stocks.

The full text of the report follows:

The completion of the Wagoner No. 1, in sec. 32, T. 14 N., R. 4 W., in Oklahoma County, Oklahoma, marked the discovery, April 5, 1943, of what is now known as the West Edmond field in Canadian, Logan, and Kingfisher counties, Oklahoma. One of the largest concentrations of drilling equipment ever used at one time was gathered together in this field, and at present, less than 2 years from the discovery date, there are more than 300 producing wells and approximately 100 wells are being drilled. Wells are located on 40-acre spacing, and the field now is about 4 miles wide and 14 in length.

There are 2 oil-producing formations, the Bartlesville sand and the Bois D'Arc section of the Hunton lime. At the present time, there are only a few wells completed in the Bartlesville sand. Most of these are being completed in the Bois D'Arc section of the Hunton lime. Present production is approximately 42,000 bbl. per day.

Samples of crude oil from both the Bartlesville and Hunton producing horizons were collected and analyzed by the U. S. Bureau of Mines. Both samples were analyzed by the Bureau of Mines Hempel Method, and the production from the Hunton lime was also analyzed for its content of 91-octane number aviation base stock.

The Hempel analyses of both samples indicate that there is very little difference between the two crude oils. Both yield 31-33 per cent gasoline, 10-11 per cent kerosine, 15-16 per cent gas oil, and 19-21 per cent lubricating distillate, and 21 per cent residuum. The sample of Hunton lime production had about 2 per cent more light gasoline than the Bartlesville sand production sample, which had 2 per cent more lubricating distillate.

A comparison with the Wilcox and Ar-

Edmond, West field — Sample 44138 — Oklahoma
Bois D' Arc, Hunton limestone Devonian — Oklahoma County
6855-7210 ft. — 14N-4W-Ind.

General characteristics

Specific gravity, 0.816 — API gravity, 41.9°
Sulphur, per cent, 0.15 — Color, brownish-green
Saybolt Universal viscosity at 100° F., 40 sec.

Distillation, Bureau of Mines Hempel Method

Distillation at atmospheric pressure, 747 mm. First drop, 27° C. (81° F.)

Fraction no.	Cut at °C.	Cut at °F.	Per cent	Sum, per cent	Sp. gr., 60/60°F.	°API, 60° F.	C.I.	S.U. visc., 100°F.	Cloud test, °F.
1	50	122	3.5	3.5	0.636	91.0	..		
2	75	167	3.6	7.1	0.665	81.3	5.1		
3	100	212	4.0	11.1	0.709	68.1	16		
4	125	257	6.3	17.4	0.735	61.0	19		
5	150	302	5.5	22.9	0.753	56.4	20		
6	175	347	5.1	28.0	0.772	51.8	23		
7	200	392	4.7	32.7	0.785	48.8	23		
8	225	437	5.2	37.9	0.801	45.2	24		
9	250	482	4.9	42.8	0.816	41.9	26		
10	275	527	6.2	49.0	0.827	39.6	27		
Distillation continued at 40 mm.									
11	200	392	4.5	53.5	0.843	36.4	30	43	10
12	225	437	5.6	59.1	0.848	35.4	29	47	30
13	250	482	5.2	64.3	0.862	32.7	32	60	50
14	275	527	5.9	70.2	0.870	31.1	33	85	65
15	300	572	6.0	76.2	0.878	29.7	34	180	80
Residuum.....			20.7	96.9	0.919	22.5			

Carbon residue of residuum, 3.5 per cent; carbon residue of crude, 0.7 per cent.

Approximate summary

Light gasoline	Per cent 11.1	Sp. gr., 0.672	°API. 79.1	Viscosity
Total gasoline and naphtha	32.7	0.730	62.3	
Kerosine distillate	10.1	0.808	43.6	
Gas oil	14.9	0.839	37.2	
Nonviscous lubricating distillate	10.5	0.852-0.871	34.6-31.0	50–100
Medium lubricating distillate	6.3	0.871-0.880	31.0-29.3	100–200
Viscous lubricating distillate	1.7	0.880-0.882	29.3-28.9	Above 200
Residuum	20.7	0.919	22.5	
Distillation loss	3.1			

Edmond, West field — Sample 44136 — Oklahoma
Bartlesville sand, Pennsylvanian — Canadian County
14W-5W-Ind.

General characteristics

Specific gravity, 0.825 — API gravity, 40.0°
Sulphur, per cent, 0.12 — Color, green
Saybolt Universal viscosity at 100° F., 41 sec.

Distillation, Bureau of Mines Hempel Method

Distillation at atmospheric pressure, 731 mm. First drop, 28° C. (82° F.)

Fraction no.	Cut at °C.	Cut at °F.	Per cent	Sum, per cent	Sp. gr., 60/60°F.	°API, 60°F.	C.I.	S.U. visc., 100°F.	Cloud test, °F.
1	50	122	1.8	1.8	0.650	86.2	..		
2	75	167	3.3	4.1					
3	100	212	4.5	8.6	0.707	68.6	15		
4	125	257	6.1	14.7	0.733	61.5	18		
5	150	302	6.0	20.7	0.754	56.2	21		
6	175	347	5.3	26.0	0.772	51.8	23		
7	200	392	4.6	30.6	0.786	48.5	23		
8	225	437	5.3	35.9	0.801	45.2	24		
9	250	482	5.4	41.3	0.815	42.1	26		
10	275	527	6.3	47.6	0.828	39.4	27		
Distillation continued at 40 mm.									
11	200	392	4.6	52.2	0.842	36.6	30	40	15
12	225	437	7.1	59.3	0.846	35.8	28	46	25
13	250	482	6.4	65.7	0.862	32.7	32	63	40
14	275	527	6.0	71.7	0.874	30.4	35	93	60
15	300	572	7.1	78.8	0.879	29.5	34	175	80
Residuum.....			20.5	99.3	0.919	22.5			

Carbon residue of residuum, 3.1 per cent; carbon residue of crude, 0.6 per cent.

Approximate summary

Light gasoline	Per cent 8.6	Sp. gr., 0.680	°API, 76.6	Viscosity
Total gasoline and naphtha	30.6	0.737	60.5	
Kerosine distillate	10.7	0.808	43.6	
Gas oil	16.1	0.838	37.4	
Nonviscous lubricating distillate	11.9	0.850-0.875	35.0-30.2	50–100
Medium lubricating distillate	7.9	0.875-0.881	30.2-29.1	100–200
Viscous lubricating distillate	1.6	0.881-0.882	29.1-28.9	Above 200
Residuum	20.5	0.919	22.5	
Distillation loss	0.7			

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Franks improved 100 percent portable rotary drilling rig offers 20 percent greater drilling capacity than Franks previous truck-mounted rigs. It is furnished with either 84 ft. two-piece open face derrick or with single piece 90 ft. telescoping derrick. The telescoping derrick can be raised and extended or telescoped and folded down over truck bed for location-to-location moving in 20 minutes. Lines and block remain strung at all times.

All essentials, including derrick, draw-works, pumps, power plant, and rotary table, compactly unitized and mounted on a single truck.

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Texas, Louisiana, New Mexico: R. M. White, 823 Neil P. Anderson Bldg., Fort Worth, Tex.

buckle production from the Oklahoma City field indicates that both the West Edmond crude oils may be expected to yield more and possibly better lubricating stocks than Oklahoma City crude oil, because the West Edmond oils contain viscous lubricating distillate, which is not present in the Oklahoma City oil. Also, the quantity of residuum is less, yet it has a higher API gravity and lower carbon residue.

The sample from the Hunton lime was evaluated for its possible content of 91-octane number aviation base stock with the following results:

1. An undepentanized portion having an end point of about 225°F., and representing 13 per cent of the crude oil had an F-3 (1-C) octane number of 84.4 with 4.6 ml. of tetraethyl lead.

2. An undepentanized portion having an end point of about 200°F., and representing 6 per cent of the crude oil had an F-3 (1-C) octane number of 88.5 with 4.6 ml. of tetraethyl lead.

3. A dependentanized portion having an end point of about 225°F., and representing 6 per cent of the crude oil brought to 7 lb. R.v.p. with 13.5 per cent of isopentane had an F-3 (1-C) octane number of 90.8 with 4.6 ml. of tetraethyl lead.

The data indicate that, if the naphtha is cut to about a 200°F. end point, depentanized, and isopentane added to 7 lb. R.v.p., then about 6 per cent of the crude oil can be utilized as 91-octane number aviation base stock.

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Remarkable New

ELGIN WATER SOFTENER

gives up to 44% more soft water

This is no time to put up with troublesome hard water lime and scale deposits. The remarkable new Elgin Water Softener turns hard water soft—keeps equipment clean and efficient — eliminates the delay and expense of shut-downs for cleaning and repairs.

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STEP UP CAPACITY OF EXISTING WATER SOFTENERS

The Double Check Manifold arrangement can be installed quickly in any make softener. This, with the added zeolite, will give up to 44% more soft water.

Write for new bulletin 603

ELGIN SOFTENER CORPORATION

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SOFTENERS ★ FILTERS ★ WATER TREATMENT ★ BOILER WATER CONDITIONING

Cook to Fisher Governor

Fisher Governor Company, Marshalltown, Iowa, announces the appointment of Allan K. Cook as its exclusive sales and engineering representative in western Kentucky and southern Indiana. He has established his offices in the McDowell Building, 505 South Third Street, Louisville, Kentucky.

Cook is a graduate engineer from the Massachusetts Institute of Technology. Since 1934 he has been connected with the Henry Vogt Machine Company and the Girdler Corporation, serving the latter firm as chief engineer of the gas processes division.

TAG sells assets

The C. J. Tagliabue Manufacturing Company has sold its assets, including good will, name and patents, to the Portable Products Corporation of Pittsburgh, Pennsylvania.

The progressive research and development policies in electronic and mechanical instrumentation that for so many years have characterized the Tagliabue organization will be continued under the local management and personnel, officials state.

The business will be operated as a separate division of the Portable Products Corporation. Among the interests of the latter are manufacturing plants in Newburgh, New York, Philadelphia and Pittsburgh, Pennsylvania.

Increase exploration

An expanded exploration and development program, designed to augment the Company's crude oil reserves, has just been announced by William F. Humphrey, president of Tide Water Associated Oil Company.

Due to the importance of developing new sources of crude oil production, L. C. Decius, vice president, has been appointed director of exploration for the Associated division and will concentrate on this program. Decius, in the service of the company for more than 29 years, is a nationally recognized geologist and has had extensive experience in geological and exploration operations outside the continental United States as well as in this country.

F. A. Menken, manager of the geological department, has been appointed assistant director of exploration. H. W. Gray, for many years manager of the land department, continues in that position.

Humphrey also announced the appointment of T. L. Wark as general manager of the production department and member of the operating committee. Wark will be responsible for all production activities in the Associated division. Wark has been associated with the company more than 25 years, in the geological, production, and engineering end of the business and in 1937 was appointed assistant vice-president, in which capacity he continues.

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For FULL GAUGE Hole

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WELDED-IN BLADE BIT IS THE OIL COUNTRY'S NO. 1 HOLE-MAKER

Alloy steel body, heat-treated; drop forged steel blades, heat-treated. Quickly replaced when worn. Fluid courses lined with special alloy bushing. Made in 2-way and 3-way types.

Hunt makes a bit to meet every drilling requirement.

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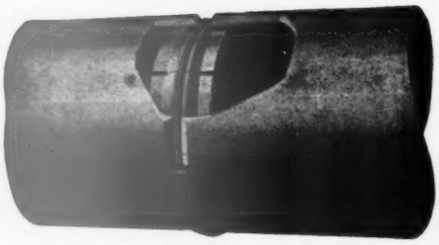

You can weld FASTER and BETTER with WEDGE Chill Rings. You can use less skilled help and get first class work and your experienced and skilled help can do much more. If you do ANY pipe welding, in refinery or for pipe lines, it will pay to investigate.

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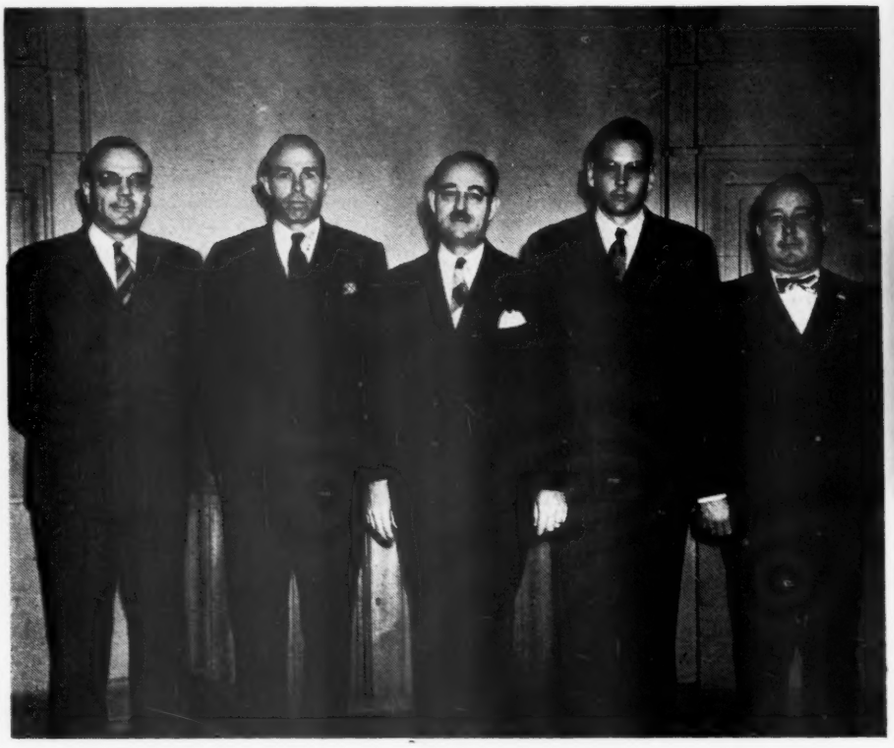
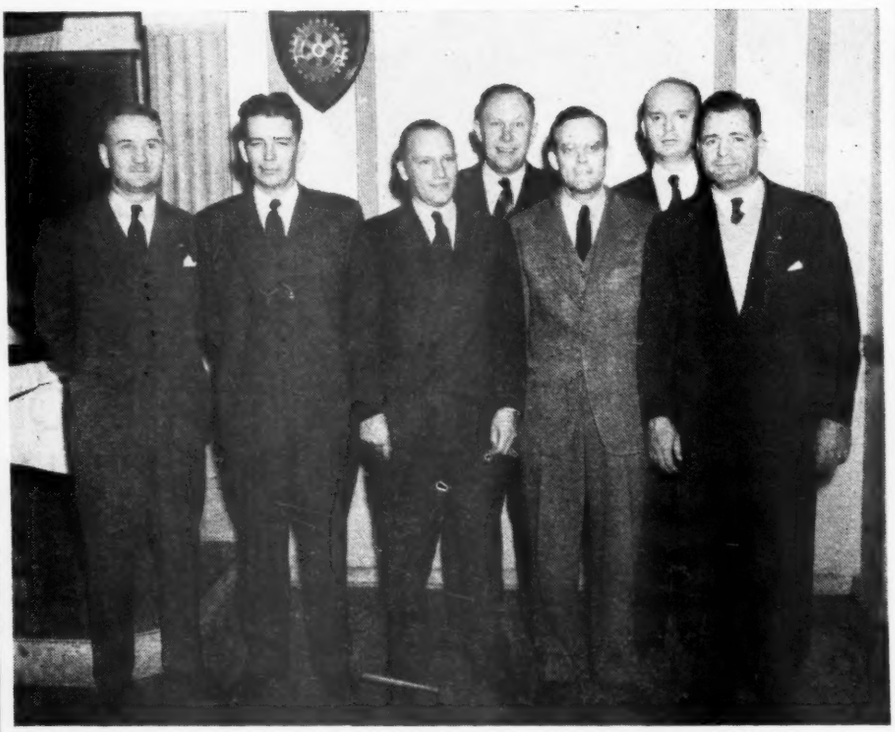


Left to right: President, Charles B. Carpenter, senior petroleum engineer, Petroleum and Natural Gas Division, U. S. Bureau of Mines, Dallas; vice president in charge of programs, Jack P. Hays, Seaboard Oil Company of Delaware; secretary-treasurer, J. W. Black, Magnolia Petroleum Company; vice president in charge of arrangements, E. J. Wacker, Jr., Magnolia Petroleum Company; vice president in charge of membership, R. U. Maddox, Big West Drilling Company.

AIME East Texas Chapter officials



Left to right: W. S. Morris, East Texas Salt Water Disposal Company, chairman of the petroleum division, AIME; John S. Bell, Humble Oil and Refining Company, member of the board of directors of East Texas Section, and retiring chairman; Robert M. Hess, Shell Oil Company, Inc., new chairman of East Texas Section; C. E. Mangold, Dowell Incorporated, board member, East Texas Section; Warren J. Jackson, Lane-Wells Company, vice chairman of East Texas Section for Dallas; Albert S. Trube, Tide Water Associated Oil Company, secretary and treasurer, East Texas, and John H. Murrell, DeGolyer and MacNaughton, member of East Texas Section and a recent speaker, A. S. Ross, The Texas Company, new vice chairman for Shreveport.

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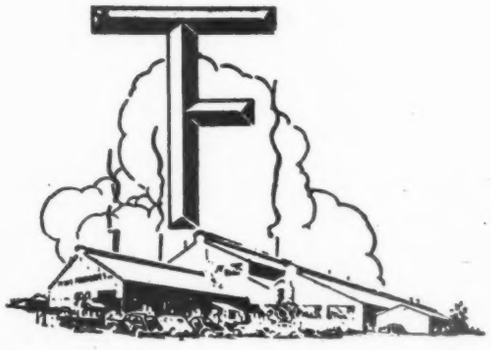

IT WILL PAY YOU TO CONSULT WITH TEXAS FOUNDRIES ENGINEERS AND TECHNICIANS ON THE POST-WAR PRODUCTS YOU ARE PLANNING . . . THE SOONER THE BETTER.

TEXAS FOUNDRIES

Organized for Service

LUFKIN, TEXAS

New appointments

C. D'W. Gibson, vice president in charge of sales of Air Reduction, has announced the following appointments.

H. F. Henriques, formerly sales manager of the north central division, is appointed general sales manager.

J. J. Lincoln, formerly sales manager of the south central division, is appointed director of sales services.

C. M. Bloodgood, who has been serving as sales manager of the Pacific Coast division, is appointed assistant to the vice president in charge of sales.

All the above new appointees will have offices at 60 East 42nd Street, New York 17, New York.

H. P. Etter, heretofore manager of the Los Angeles district of Air Reduction, is appointed sales manager of the Pacific Coast division with headquarters in the Mills Tower Building, San Francisco.

Five stars in flag

Five gold stars proudly grace The Cooper-Bessemer Corporation's Maritime Commission "M" Burgee, indicating the success of this company's efforts to meet government wartime demands for critically-needed diesel engines and parts.

Award of the fifth gold star was announced to employes by B. B. Williams, chairman of the board, following its receipt from Washington. Williams admonished Cooper-Bessemer employes "to continue your program of furnishing our men on the front lines with what it takes on time, and especially now when there is so much talk of shortages on the production front."

Cooper-Bessemer received the "Maritime 'M'" burgee on December 18, 1942, and each of the five gold stars it bears have been awarded at regular intervals since. These stars are awarded in recognition of a continuation of outstanding war production that merited the initial honor.

The company, which has devoted its facilities 100 per cent to war production, also flies the Army-Navy "E" awarded in March of last year and the United States treasury department's Minute-Man flag for 100 per cent participation of its employes in war bond subscription.

Firm name changed

The name of Rockford Drilling Machine Division of Borg-Warner Corporation, at Rockford, Illinois, has been changed to Rockford Clutch Division.

With three factories in war production, and a corresponding increase in its engineering activities, the division has acquired the Borg-Warner research laboratory at Rockford and will operate it as the Rockford Clutch Engineering Laboratory, it was announced.

National Carbon officials

C. O. Kleinsmith D. B. Joy

C. O. Kleinsmith has been elected a vice president of National Carbon Company, Inc., a unit of Union Carbide and Carbon Corporation. Kleinsmith was formerly general sales manager for the company's "Eveready" products. Prior to his appointment to that position, 2 years ago, he was sales manager for eastern United States. He joined the company in 1919.

Kleinsmith announced the appointment of D. B. Joy as general sales manager for carbon products. Joy joined National Carbon Company in 1923 after graduating from Massachusetts Institute of Technology. He was made director of the company's process engineering laboratory at Fostoria, Ohio, 10 years ago, and in 1941 became assistant superintendent of the Fostoria factory. He was made product manager last year.

Mr. Kleinsmith also announced the appointment of R. P. Bergan as general sales manager for the company's consumer and related products.

AMERICAN ROLLER BEARINGS HEAVY DUTY

When we say *super service*, we mean just that! Because AMERICAN SUPER HEAVY DUTY ROLLER BEARINGS are *specially* built for applications requiring *super* strength . . . *super* performance . . . *super* endurance. They are not just "stock" bearings. Often they are designed to exact specifications for the job they are required to do. Their vital, extra capacity to render continuous 24-hour-a-day performance in the heaviest equipment built, under the most adverse service conditions to be encountered in modern industry, is the reason why, for more than 25 years, AMERICANS have been first choice with manufacturers and designers of heavy industrial ond oil country machinery. Once adopted, no manufacturer has ever had to switch from AMERICANS. Write today for complete technical details.

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PITTSBURGH PENNSYLVANIA
Pacific Coast Office: 1718 S. Flower St., Los Angeles, Calif.

AMERICAN
Heavy-Duty ROLLER BEARINGS

Tube Turns president

R. E. Fritsch, vice president of Tube Turns, Louisville, Kentucky, since 1929, has been elected president, succeeding Walter H. Girdler, Sr., who died on January 7. Fritsch became associated with Girdler when Tube Turns was originally organized and he has had a major part in the firm's growth.

R. E. Fritsch

Fritsch continues as vice president and a member of the board of directors of The Girdler Corporation, of which Tube Turns is an affiliate. He is a member of the American Society for Metals and the American Welding Society.

Eastern sales manager

Announcement has been made of the appointment of Chas. W. Springer as manager of eastern sales by the Graver Tank and Manufacturing Company, Inc., of East Chicago, Indiana.

C. W. Springer

Springer, formerly sales manager, barrel division, Jones and Laughlin Steel Company, and familiar to many as a representative of the Chicago Bridge and Iron Company, brings to the Graver organization a well rounded background of executive sales direction in the steel plate and allied fields.

Springer will direct all Graver's east coast sales activities from the company's offices at 424 Madison Avenue 17, New York City.

Appointed manager

C. H. Lang, General Electric vice president and manager of apparatus sales, has also been given the direction of application and service engineering in the company's apparatus department, according to an announcement by R. C. Muir, vice president and general manager of that department.

In this connection, the appointment of A. K. Bushman as manager, application and service engineering, apparatus department, is announced by Vice President Lang. For more than 17 years Bushman has been district manager of General Electric's industrial division at Chicago. He will now make his headquarters in Schenectady.

On South American trip

Security Engineering Company, Inc., is sending R. L. (Bob) Gollum on a six months' South American sales trip, on which he will cover all the major oil fields on the northern part of the continent.

Gollum, who has represented Security out of both the Whittier, California, home office and through the export offices of the company in New York, will bring South American oil operators the latest information on the Security line of tools, which include the Sievers reamer; Securaloy, drillable oilfield metal; the company's completion and production tools; the new Security casing scraper; a complete line of cast and forged-steel valves and cast-steel fittings; and since Security recently bought out Crum-Brainard Company, Ltd., Gollum will also represent on the Pan-American trip the Crum-Brainard roller bit.

Leaving Los Angeles January 2, he was scheduled through Mexico City and Balboa to Maracaibo, where he will cover the vast oil fields about the lake; thence to Caracas and Barcelona and the big fields of Quirequire, Caripito, Jusepin, and Santa Barbara.

March 6 will see Gollum in Port of Spain, Trinidad, with visits to San Fernando, Point-a-Pierre, Siparia, Point Fortin, and Palo Seco. After a return to Maracaibo he will hop to Colombia, visiting Barranquilla, Barranca Bermeja, and Bogota. In Ecuador in May he is slated for Guayaquil, Quito, and various Ecuadoran fields. In Peru he will make his headquarters in Lima. June will see him returning via Bogota to Balboa and thence home through Mexico to the West Coast.

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"BUILT to do the JOB"

Stamina—the ability to "take it" for long periods of real tough going *doesn't* come as an *accessory* to Oil Field Engines. You *can't buy* it as an extra, it's either *designed* and *built into* every part of the engine or it isn't there at all.

MM Oil Field Engines *don't* have to be coddled because they have all the performance features *"built-in"*—Features that guarantee real low cost performance under tough conditions—Features that will give *you* assurance of 24 hour operation year in and year out in fair weather and foul—Features that will give you low cost, efficient, trouble free operation. Force-feed lubrication, valve-in-head design, high turbulence combustion chamber, controlled cooling, unit construction, automatic magneto cutout, automatic temperature cutout, flyball type variable speed governor, entirely enclosed in crankcase, oil wash air cleaner and ample size oil filter—*these features and many others are "built in" on every MM oil field Engine.*

MM Oil Field Engines are built in 8 sizes to fit most every oil field application:

165-4A, 3⅝x4, 4 cyl.	CUA, 4¼x5, 6 cyl.
206-4A, 3⅝x5, 4 cyl.	HUA, 4⅝x6, 6 cyl.
KUA, 4¼x5, 4 cyl.	MEU, 8x9, 4 cyl.
LUA, 4⅝x6, 4 cyl.	NEU, 8x9, 6 cyl.

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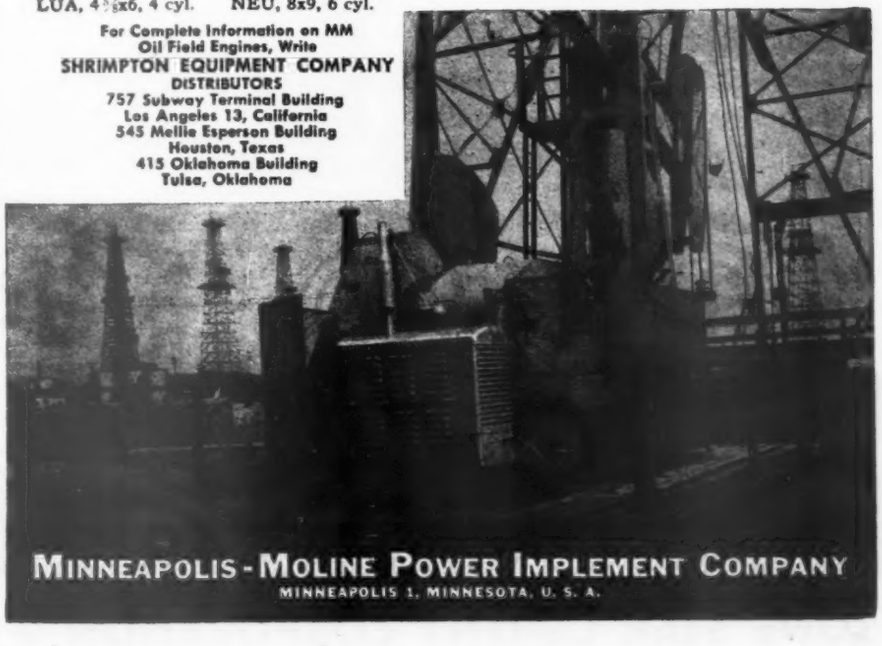

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MINNEAPOLIS 1, MINNESOTA, U. S. A.

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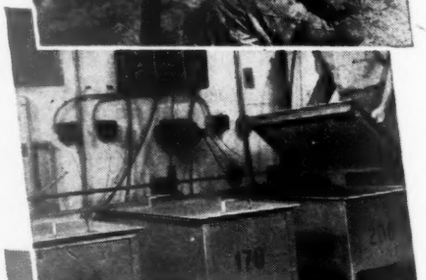
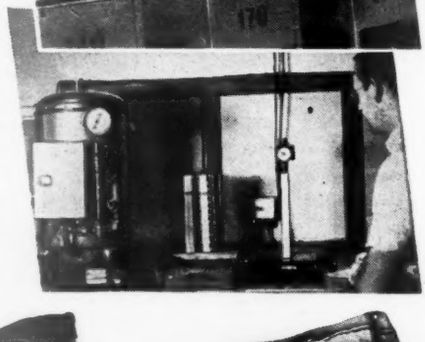
BASED ON UNREMITTING EFFORT TO MEET THE OIL MAN'S EXACTING REQUIREMENTS

Day-by-day contact with drilling problems at the rig, combines with



Continuing research in Lone Star Oil-Well Cement Laboratories, to provide



Dependable performance, maintained by rigid quality control, assuring bag-by-bag uniformity.

SUCCESS of the entire oil-well investment depends upon a few hundred bags of cement. That's why we go all out to assure outstanding performance . . . performance proved behind thousands of miles of pipe: In deep wells, 'STARCOR'* for strong, dense, permanent shut-offs and high sulphate resistance. In deepest wells, 'TEXCOR'* with extra long thickening time and high sulphate resistance. In moderate-depth wells, 'INCOR'* for earlier drill-out. And LONE STAR CEMENT for dependable all-around service. Four great performers . . . use the cement that fits your well. *Reg. U. S. Pat. Off.

RESULT: OUTSTANDING PERFORMANCE, TODAY AND TOMORROW

LONE STAR CEMENT CORPORATION • DALLAS • HOUSTON

Heads research

B. F. Hunter has been named consulting engineer in charge of research and sales engineering for the Honan-Crane Corporation, subsidiary of the Houdaille-Hershey Corporation, according to an announcement by C. R. Crooks, vice president in charge of sales.

B. F. Hunter

Hunter assumed his duties with Honan-Crane January 1, after 19 years as chief lubrication engineer for the Gulf Oil Corporation and the Gulf Refining Company. For 6 years prior to his association with Gulf, he was chief industrial lubrication engineer for The Texas Company.

In addition to his status as consulting engineer, Hunter will also serve as chief of research. He comes to the Honan-Crane Corporation with a background rich in experience and a record of accomplishment that sets him high among the country's foremost lubrication engineers.

In acquiring the services of Hunter the Honan-Crane Corporation puts new emphasis on its program of scientific approach to oil purification as applied in modern industry. Hunter will direct the research work in Honan-Crane's laboratories at Lebanon, Indiana, as well as special projects and more exhaustive inquiry in leading research institutes. Functioning also as head of sales engineering, he will make his wealth of experience available to Honan-Crane's oil purification engineers and to his many friends in industry throughout the United States.

Hunter is preparing at this time a series of technical articles for Honan-Crane on the relation of oil purification to the satisfactory lubrication of modern engines and other industrial equipment. These articles will be printed and released as they are completed. Persons who wish to receive copies of them should send their names to Honan-Crane for placement on the mailing list, to receive the articles as published. Address: Honan-Crane Corporation, 570 Wabash Avenue, Lebanon, Indiana.

Manager London office

Appointment of C. T. Longcroft as manager of the London office of Oil Well Supply Company is announced by F. F. Murray, president. Longcroft is the former manager of sales in London.

At the same time, announcement was made of the retirement after 31 years' service of Ashley Carter, former manager of the London office. Carter served "Oilwell" as its London manager during the dark days of the "blitz" and kept "Oilwell's" facilities in operation in that area despite the havoc of war.

Carter has been prominent in petroleum circles for many years and is now vice president and honorary secretary of the Institute of Petroleum. He had successfully dealt with oilfield machinery and equipment problems in the London area and has made direct contacts with oil companies on the Continent as well as in the Near East and in the Far East.

Houdry royalty plan

A running royalty financial arrangement for licensees of Houdry catalytic cracking processes has been announced by the Houdry Process Corporation, Wilmington, Delaware. Arthur V. Danner, executive vice president, in making the announcement, pointed out that the plan is applicable to licenses for both the Houdry fixed-bed and the thermofor catalytic cracking processes, and covers catalytic cracking operations generally, regardless of end products.

The terms are 5 cents per bbl. of fresh feed charge, with no additional cost for recycling or treating for aviation gasoline production. The paid-up licensing plan is, of course, still available. "The new plan," Danner explained, "is designed especially to aid the small refiners and assist them in sharing the expanded markets for catalytic motor fuel and specialty products. It is backed by the engineering service and laboratory facilities of the Houdry organization, which is serving 59 catalytic cracking plants throughout the country. All are now contributing in the production of aviation base stock for war."

Now a 5½" x 2½" TUBING CATCHER
FOR YOUR 10,000 FT. WELLS

Built to catch 10,000 feet of 2½-inch tubing automatically in 5½-inch casing—an impact load of over 50 tons!

Look at the greater gripping area of the DOUBLE E 5½x2½-inch Three-Step Tubing Catcher in the picture. Note the large by-pass areas and the general rugged construction. These are several of the improved features of DOUBLE E which provide you with greater protection against falling tubing, wedged catchers, and damaged casing. In fact, it has over twice the slip area of any other catcher.

An anchor attachment is included to increase the efficiency of deep pumping wells, functioning with either hydraulic or rod operator pumps.

Once you have used the DOUBLE E, you'll always be grateful we told you about them. Obtainable at pre-war prices through your supply store.

"DOUBLE E" Products

SAY "DOUBLE E" WHEN YOU WANT THE BEST!

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ACME DRILLING & FISHING TOOLS

TWO "OLD RELIABLES" NOW ONE

THE PATTIN BROS. CO

The World's Standard of Quality in Oil Field Equipment - - -

Acme — Since 1900

Pattin — Since 1888

Combined Facilities for a Post War Forward March

SINCE 1900, Acme's Cable Drilling and Fishing Tools have *led* the vanguard in meeting highest performance standard demands of seasoned Oil Men everywhere. Famous for their *constant* dependability, when you use Acme Tools, "you don't *guess* — you KNOW they're the world's *best.*"

Since 1888, Pattin Engines, Powers, Compressors and Tanks have *held* "top-billing" for RUGGEDNESS — the *safest* foundation for efficient, economical service, in a field where enduring performance *counts most.* Experienced Oil Men agree that: "Pattin Perfected Products last longer and serve best, because they're built stronger than all the rest."

Now Acme and Pattin — two "Old Reliables" — are ONE; Acme having bought outright the entire business of Pattin Bros. Co.

With these combined facilities, Acme is obviously "forging ahead" — building for greater leadership in *product values* — and, in the postwar era, will be prepared to serve a wider world-market, *both* drillers and producers.

Even today, while busy on other essential orders, every effort is made to provide our customers with *"must"* equipment and fishing service — to aid in meeting an unprecedented demand for Victory-speeding petroleum products.

They're "Tougher than Tough!"

Acme Drilling Bits — First choice of Drillers "fighting for *extra footage.*" Forged to their own specifications, of finest bit steel, and fashioned to perfectly balanced proportions — by 45 years of specialized craftsmanship. They just *naturally* "stand the gaff" — LONGER . . . Made in regular Mother Hubbard or Tapered Shank Patterns. Specify Acme (Alloy Steel) Drilmor Bits for drilling formations too hard for standard bits.

Fig. 108
See
Acme — Composite Catalog.

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POWERS — COMPRESSORS

"GLUTTONS for Life-Long Punishment"

Write TODAY for New Catalog

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PARKERSBURG, W. VA.

PATTIN BROS. DIV.
of Acme Fishing Tool Co.
MARIETTA, OHIO

Export Office: 19 Rector St., New York 6, N. Y.

Export division

In order to facilitate handling of its extensive export activities, Gardner-Denver Company, Quincy, Illinois, has established the main office of its export department in New York City, the company announces.

G. V. Leece

This arrangement will enable the company to cooperate to best advantage with all its export customers in providing essential equipment, such as air compressors for industrial use, rock drills and compressors for mining and construction, and pumps and drilling engines for oil fields.

Located in the Woolworth Building, New York City, the new Gardner-Denver export office will be headed by G. V. Leece, vice president of the company, who will now have charge of the entire export division. Leece assumes this position after more than 20 years' experience in the Gardner-Denver Company as manager of the Los Angeles office, Pacific Coast manager and, for the last 5 years, manager of the New York office, where his activities have been largely concentrated on export.

Associated with Leece in the New York export office are S. T. Brown, assistant manager, and Harold Weber, assistant sales manager. Brown for many years has been in the company's Denver plant where he has been actively identified with export drill business. Weber has been associated with the New York office of the company.

Edward Church will now be associated with the Denver office in the export division and will be concerned with the further development of Gardner-Denver rock drills and mining equipment now utilized in all foreign fields and manufactured in that plant.

C. E. Kaiser, who was assistant export manager under Church, will be in charge of the export division in Quincy.

Expansion program

A leading manufacturer in the industrial rubber business for 85 years, officials of Hewitt Rubber Corporation of Buffalo, New York, state that its recently-announced expansion program will permit increased output of conveyor belts, transmission belts, and many types of industrial hose. The company also will enter the field of latex foam and molded rubber articles for use in industry.

In making the announcement, Thomas Robins, Jr., president of Hewitt, revealed that wartime requirements have greatly expanded company facilities for production of these articles. The new equipment at the main Buffalo plant more than doubles the prewar capacity of mixing rubber and of forming the raw stocks into sheets. These are two basic operations in the manufacture of all industrial rubber products.

Receives "E" Star

The Chain Belt Company of Milwaukee has just received another Army-Navy "E" star. This makes the fourth time that official commendation from Washington has been directed to Chain Belt. The company received its original Army-Navy "E" pennant award September 19, 1942.

In addition to the company's regular products which are widely distributed among other producers of war equipment and more essential civilian needs, Chain Belt Company has produced since 1941 medium size howitzers, pack howitzers, 120 millimeter anti-aircraft guns, refuse grinders for transports and landing barges, tank turrets, gun shields, traction shoes for amphibious landing craft, and ammunition hoists for other naval units.

Elastic Stop Nut president

John R. Munn

John R. Munn, a director of the Elastic Stop Nut Corporation of America since 1927, has been chosen as president of the company to fill the unexpired term of the late William T. Hedlund.

Munn, who is also chairman of the board of Munn and Steele, Inc., manufacturers of insulating materials, is a past president of the Princeton Engineering Association, and served as a member of the United States Food Administration in the last war.

Personnel changes

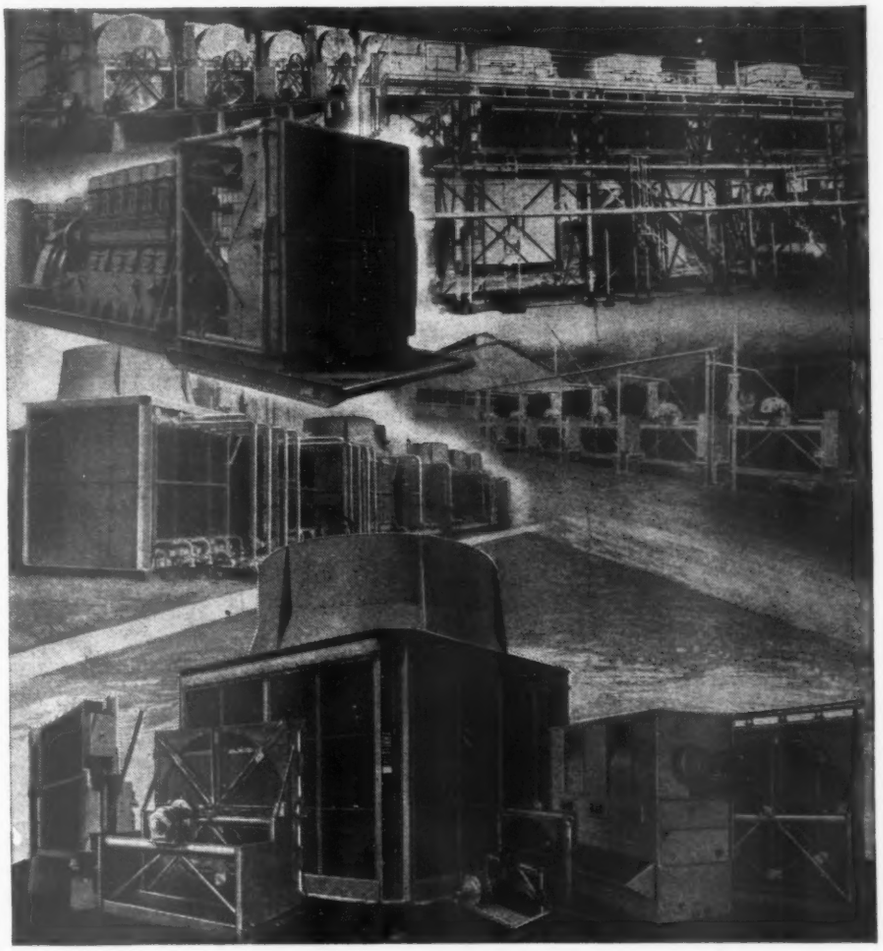
E. S. Dulin, president of Byron Jackson Company and of International Cementers, Inc., announces the following personnel changes.

John D. Chesnut, formerly manager of the patent and new development department of Byron Jackson Company and executive vice president of International Cementers, Inc., assumes additional full time duties as general manager of I.C.I.

Ward B. Tennis, acting general manager of International Cementers, Inc., becomes manager of the chemical department specializing in acidizing of oil wells and chemical treatment of industrial heat exchange equipment for the removal of scale and sludge. Recent staff additions to this department include C. S. McElrath and P. E. Paules, chemical engineers.

Jack S. Smith, for many years associated with Byron Jackson Company, joins International Cementers, Inc., as manager of the cementing department. In addition to conventional oil well cementing, this department shortly will offer, as licensees of The Dow Chemical Company and Dowell Incorporated, their recently developed plastic cementing service.

HEAT TRANSFER
SPECIALISTS
TO THE OIL FIELD AND
PETROLEUM INDUSTRIES



Changes come fast in the oil industry. New processes replace old, and make new problems in heat transfer. For more than a quarter century, Young engineers have worked with petroleum and chemical engineers, solving new problems as they came. That's why Young stands ready now with the experience, "know how", and manufacturing facilities to design and produce special or standard heat transfer units for every need.

YOUNG
HEAT TRANSFER ENGINEERS

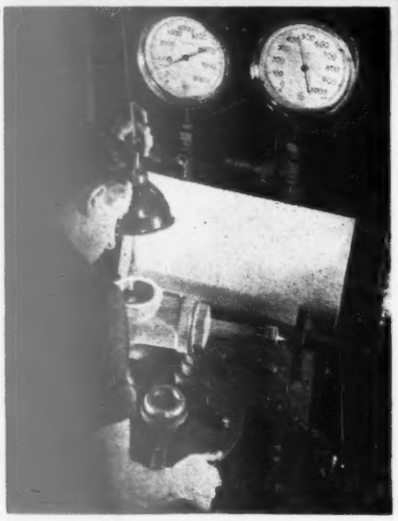
Manufacturers of Oil Coolers • Gas, Gasoline, Diesel Engine Radiators • Intercoolers • Heat Exchangers • Engine Jacket Water Coolers • Unit Heaters • Convectors • Condensers • Evaporators • Air Conditioning Units • Heating and Cooling Coils • And a Line of Aircraft Heat Transfer Equipment.

YOUNG RADIATOR COMPANY, Dept. 285-B, Racine, Wis., U.S.A.

Mid-Continent Distributors
THE HAPPY COMPANY
Tulsa, Oklahoma

West Coast Distributors
A. R. FLOURNOY COMPANY
Bell (LosAngeles), California

Riqid *TESTS* at every vital step in production quard the dependable *QUALITY* of LUNKENHEIMER VALVES



Nothing is left to chance in producing Lunkenheimer Valves. Exacting tests with the most advanced modern equipment are made at each important point in manufacture. Even final packaging for shipment must meet rigid specifications.

This may be producing valves the "hard way" . . . but for Lunkenheimer it's the *right* way, since it safeguards a reputation for quality that is our proudest possession.

TEST PRESSURES FAR EXCEED RATED PRESSURES

Every Lunkenheimer valve is given a thorough test at pressures far above its rated working pressure. Valves are tested on both sides at high and low pressure for seat tightness, and then given a shell test. The slightest leak causes rejection.

Today, with greatly stepped up production schedules, maintenance men appreciate more than ever the rugged durability, efficiency, and longer service life of Lunkenheimer Valves —the less attention and fewer repairs they require.

Lunkenheimer Distributors are located in all important industrial centers. There is one near you, ready at all times to assist in solving your problems of maintenance and operation.

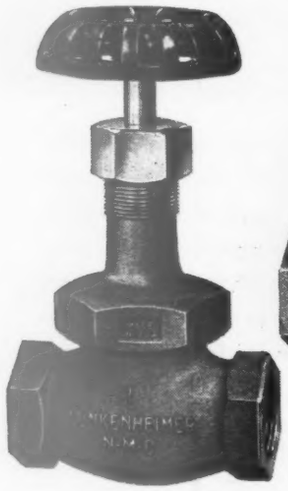


Fig. 123
"N-M-D" Globe
(Non-Metallic Disc)

Fig. 2125
125 lb. S. P. Bronze Gate
Double Disc, Rising Stem

BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S.P.; BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

ESTABLISHED 1862

THE LUNKENHEIMER CO.

"QUALITY"

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Heads engineering

David C. Prince, vice president of General Electric Company, has taken charge of the company's General Engineering Laboratory, the activities of which will be broadened to include the requirements of the entire company, it has been announced by President Charles E. Wilson. This change from the responsibilities of application engineering for the apparatus department became effective January 1. Prince has also been chairman of the company's special planning committee.

A graduate of the University of Illinois in 1912, Prince's service with G. E. has been continuous except for 5 years beginning in 1914, which he spent with the Illinois Public Utilities Commission and as an officer in World War I. He was for several years associated with Dr. E. F. W. Alexanderson, world famous radio pioneer, was a member of the research laboratory staff and subsequently became research engineer on switchgears and manager of commercial engineering. Prince is a past president of American Institute of Electrical Engineers.

Name Changed

The corporate title of the Catalytic Development Corporation of Marcus Hook, Pennsylvania, has been changed to Houdry Process Corporation of Pennsylvania. This corporation is the research and service subsidiary of Houdry Process Corporation, Wilmington, Delaware, with research headquarters in the Houdry laboratories at Marcus Hook and offices in the Lewis Tower, Philadelphia, Pennsylvania.

Named board chairman

Rae F. Bell, former first vice president of the A. O. Smith Corporation, has been elected chairman of the firm's board of directors to succeed the late L. R. Smith, President W. C. Heath announces.

Bell was elected by the board of directors at its meeting January 11. He started with the corporation in 1923 as a vice president, and in 1937 was elected first vice president. He became a board member in 1925.

At the same meeting Anthony von Wening, formerly a vice president of the Continental Illinois National Bank and Trust Company, of Chicago, who joined the A. O. Smith Corporation in 1940, was elected vice president and controller. Other officers were reelected as follows:

W. C. Heath, president; John M. Floyd, vice president in charge of manufacturing; R. Furrer, vice president in charge of engineering, and J. J. Stamm, secretary and treasurer.

POWER PLANT FOR SALE

May be purchased complete or in separate units. Hope 4-cyl. Vertical Gas Engine, 150 HP; size 12¼" x 13"; with McCord Force Feed Lubrication, K-W High Tension Ignition, and oil filter. Direct connected to Allis-Chalmers 240 V., 280 amp., 3 phase, 60 cycle, 277 RPM, AC Generator, Western Elec. Exciter. Switchboard. For further details, prices, and photo of complete installation, write

SHUNK MFG. CO. • Bucyrus, Ohio

GE men advanced

Harold A. White, district manager of the industrial division of General Electric Company for the Southwestern district, has been named district manager of the apparatus department for the same district by Vice President Chester H. Lang. He succeeds W. B. Clayton, who as a commercial vice president now becomes a member of the president's staff.

White, a native of Revanna, Nebraska, and graduate of the University of California in 1915, entered the employ of General Electric in its test course the same year. In 1916 he was made a student salesman in the small motor division with headquarters in Lynn, Massachusetts, and the following year was transferred to the Houston office as salesman in the motor division. In 1917, during World War I, he entered military service, returning to General Electric in 1919 as salesman in the Dallas office. He was promoted to manager of the El Paso office in May, 1924, and in July, 1939, became Southwestern district manager of the industrial division.

To coordinate the company's widely diversified interests and afford better service to wartime customers, Clayton is one of 10 commercial vice presidents, representing every sales district of the company in the country, to be assigned by President Charles E. Wilson to the new organization set up by E. O. Shreve, vice president in charge of customer relations. Both Clayton and White will continue to maintain headquarters in Dallas.

H. A. White

W. B. Clayton

Clayton entered the testing department of General Electric at Schenectady in 1905, remaining approximately 3 years. He went to Dallas in 1911 with the Southwest General Electric Company. During World War I, he joined the army and was commissioned a captain.

When the Southwestern district was formed in January, 1924, he was appointed district manager of the central station department and in 1929 in addition to these duties, he became the assistant district manager. In January, 1940, he was made district manager and on March 2, 1942, he was appointed commercial vice president of the company.

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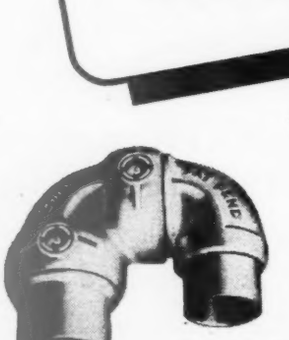
Harrisburg Seamless Steel Oil Field Products — Pipe Couplings, Pump Liners and Pipe Flanges offer a new standard for strength and thread accuracy. They are made from special analysis steel. Added protection for the sturdy threads is provided by means of the Harrisburg electro-galvanizing process which prevents galling, stripping and rusting. All types and sizes.

Harrisburg Makes: Alloy and Carbon Steel; Seamless Steel Cylinders, Liquefiers, Pipe Couplings and Slush Pump Liners; Drop Forgings and Drop-Forged Steel Pipe Flanges; Coils and Bends.

HARRISBURG STEEL CORPORATION
HARRISBURG, PENNSYLVANIA

MORE MILES
TO THE FOOT...
with
CHIKSAN

Style No. 50
Special



Style No. 10
Special

With wells going deeper and deeper, it may not be long until depths will be stated in miles ... not feet! In any case, to get the longest mileage in service per foot of Rotary Hose, be sure to use CHIKSAN Ball-Bearing Swivels for end connections. The same heavy duty CHIKSAN Swivels which provide complete flexibility in Chiksan All-Steel Rotary Hose can protect your rubber hose and make it last longer. With Chiksan Ball-Bearing Swivels as end connections, your rubber rotary hose will give you more miles to the foot!

Distributors: **Gulf Engineers, Inc.; Well Equipment Mfg. Co.**
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CHIKSAN
TRADE MARK REG.
BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES
CHIKSAN COMPANY
BREA, CALIFORNIA

Eastern Venezuela service

Houston Oil Field Material Company, Inc., Houston, Texas, has recently opened a cutting and fishing tool service point in Eastern Venezuela. This branch, which renders all phases of cutting, fishing, sidewall coring, and other rehabilitation services, will be centrally located at one of the drilling camps. The South American branch will be under the supervision of C. G. Wheeler who has served with Homco's cutting and fishing tool department more than 15 years.

Homco is offering the same cutting and fishing tool service in South America that has been available for many years in North America. Tools available include inside and outside cutters, "Little Inch" drill pipe for use with inside cutters, circulating and jackscrew releasing overshots, circulating and releasing spears, drills and small bits, and all auxiliary equipment needed in the operation of these tools. The Homco wire-line core retrieving sidewall coring tool will also be available in Eastern Venezuela.

Heads L. A. Nomads

The election of officers and talks by the past presidents were the features of the annual meeting of the Los Angeles chapter of Nomads. The meeting was a closed business session confined to Nomads. The officers selected for the coming year were: Elmer R. Smith, president; William McGraw, vice president; J. V. Robinson, secretary; Fred Tyler, treasurer; H. E. Cassidy, sergeant-at-arms; C. M. Byron, assistant secretary; Waldo Moore, assistant treasurer; Custer Morrow, deputy sergeant-at-arms; Henry Pullman, regent, and Roland E. Smith, regent.

Elmer R. Smith

Elmer Decker, first president of the chapter, spoke on the aims and objectives of the Nomads and gave a history of its founding in 1938. Ted Sutter, second president, told of the organization work done to form the association and to get its nationalization. Ernie Fowks then spoke of the activities of the other chapters at Houston, New York, and Tulsa and of the inter-chapter relationship.

Henry Pullman, probably the most widely travelled of all Nomads in the organization, discussed the standing the organization has achieved in foreign fields. Roland Smith, as retiring president, described the workings of the Los Angeles chapter and its growth during the past years.

BUY WAR BONDS

To larger quarters

Announcement is made by The Lincoln Electric Company, Cleveland, Ohio, of a new address for its Peoria office.

The new office, in charge of L. W. O'Day, manager, is now in larger quarters in the Electrical Building, 214 Second Street, Peoria, Illinois. O'Day has been a Lincoln arc-welding engineer for 17 years in the Chicago district. He has been manager at Peoria for 4 years.

The new facilities, which are situated in a building having approximately 25,000 ft. of floor space, provide ample quarters for service, spare parts and engineering and welding demonstrations.

Film available

Aeroquip Corporation's new sound and color film, "Saving Hours for Victory" is now available for showings throughout the United States, the company announces. This 16 mm. talking film provides actual field and shop demonstrations of the quick-detachable features and replacement operations covering Aeroquip self sealing couplings and flexible hose lines and fittings, which are standard equipment on a large part of American aircraft, and open a new field of industrial application to petroleum equipment involving hydraulic or pneumatic controls and related operations.

Prints of the film are available to maintenance and service organizations. Running time is 10 minutes. Send requests to Clarke H. Field, Aeroquip Corporation, Jackson, Michigan.

To improve mills

Expressing faith in the future demand for steel, Irving S. Olds, chairman of the board of directors of United States Steel Corporation, has announced a $50,000,000 improvement program for the corporation's Gary, Indiana, mills.

In making the announcement, Olds praised the collective efforts of pioneers in iron and steel who under free enterprise "have brought forth in this nation the mightiest and most modern and productive steel mills in the world."

He pointed out that the United States could not have aggressively carried on a global war without such a national asset.

Modernization of the Gary mills to keep pace with future demands of the automotive industry will be undertaken as soon after the war as conditions will permit, U. S. Steel's chairman reported.

MECHANICAL ENGINEER, leading manufacturer of drilling and production tools, located in Southern California, has opening for man, 25-35, pref. M.E. degree, should have had some experience in design and/or oil field operation. We sincerely believe this to be a worthwhile opportunity for the right man. Salary will be in line with past record and ability. Write fully giving outline of personal data and experience for past ten years. Enclose small photo is possible. Address Box 24, Petroleum Engineer, Dallas, Texas.

After time-tested, quality Fel-Pro Gaskets, Packings and other Sealing Materials are installed, there's no escape for wasteful, trouble-making "little drips" of Water, Oil, Steam, Chemicals.

In military service, in aircraft and other war industries, Fel-Pro products are meeting every possible sealing requirement.—And there's no shortage of Fel-Pro Sealing Materials; even those "drafted for the duration" have been successfully replaced by new, specially developed, improved Fel-Pro products.

Send today for FREE Fel-Pro Folder containing 36 actual samples of sealing materials, applications, engineering data, etc.

Felt Products Mfg. Co.
1535 Carroll Ave., Chicago 7, Ill.

This pair of Gould Centrifugal Pumps, direct-connected to single cylinder, and four-cylinder Wisconsin Air-Cooled Engines, are engaged in a salt water disposal pumping operation for the Ohio Oil Co., at Edmond, Okla.

Wisconsin Engines on the job are performing dependable, heavy-duty service in various types of applications in the oil industry, as well as in many other industries. These engines have "what it takes" for continuous duty on any kind of a job within their power range. Specify "Wisconsin Air-Cooled Engine" on your equipment.

WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy Duty Air-Cooled Engines

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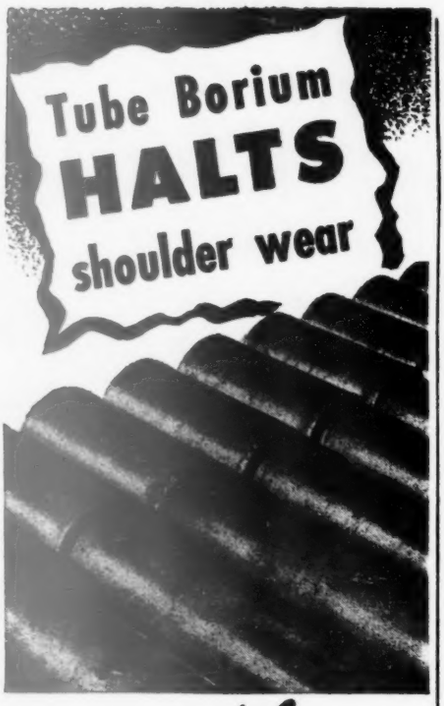
Oil field distributors for Wisconsin Engines and all types of utility units.

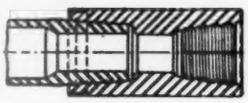


Doubles tool joint life

For fifteen years Tube Borium has been used on drilling bits to increase cutting speeds and drill more out-to-gauge hole. Now you can use this same alloy to greatly prolong the life of your tool joints!

An exceedingly small quantity of Tube Borium welded in a ring around the shoulder not only doubles tool joint life—even under the toughest operating conditions—but maintains over all joint strength and correct elevator contour. Applications are economically made on both new and resleeved joints.

APPLICATION: Accepted method of application is to under-cut new or resleeved joints at the shoulder to form a recess ⅛" deep by 1½" wide. The recess is then filled by welding in with ⅜" Electric Tube Borium to form the wear resistant inlay.



Write for this special Stoody engineering bulletin describing in detail hard-facing procedures on tool joints—no obligation.

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1142 WEST SLAUSON, WHITTIER, CALIF.

STOODY HARD-FACING ALLOYS
Retard wear . . . Save Repair

Thermoid buys Grizzly

F. E. Schluter, president of Thermoid Company, Trenton, New Jersey, has announced plans to purchase Grizzly Manufacturing Company's west coast plant and equipment located at Los Angeles, California. The purchase will include the complete line of Grizzly oil field, industrial rubber, and aviation products and all patents covering those products, including inventories and accounts receivable.

The announcement states that there will be no change in the Grizzly line of industrial and oil field products and Grizzly trademark will be continued on those products by Thermoid for a limited period of years. Walter Smith, vice president and general manager of Grizzly Manufacturing Company, will continue for a limited time as manager of the Los Angeles plant.

This acquisition will supplement Thermoid's already broad lines of oil field and industrial rubber products. All Grizzly oil field products, including rotary hose, slush pump suction hose, brake blocks, drill pipe and tubing protectors, wire line savers, and blowout preventers, will continue to be manufactured in the Los Angeles plant.

Grizzly rotary hose and other oil field products have long maintained an outstanding position in the oil fields. These products will be combined with Thermoid's line of oil field products in a combined sales program. The warehouses now maintained by Grizzly at Houston, Texas, Oklahoma City, Oklahoma, Bakersfield, California, Casper, Wyoming, and Alberta, Canada, will be continued. Grizzly Manufacturing Company, of Paulding, Ohio, has agreed to withdraw from the manufacture and sale of oil field products and has entered into a non-competitive agreement covering other products made at the Los Angeles plant.

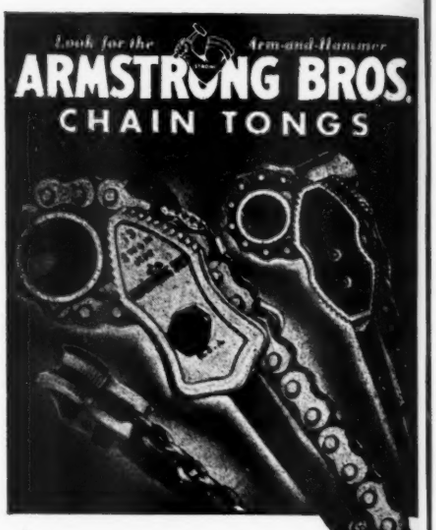
Grizzly industrial rubber products, such as air hose, steam hose, suction hose, packing and transmission and conveyor belting, will also continue to be manufactured at the Los Angeles factory.

New products for Thermoid's industrial rubber division will be hydromatic press pads for factories and patented tail wheels, now standard on many war planes and visualized for important industrial uses on factory mobile equipment.

District sales manager

W. I. Galliher, executive sales manager of the Columbia Chemical Division, Pittsburgh Plate Glass Company, announces the appointment of Walter T. Johnson as district sales manager in Chicago.

Johnson, who received his chemical engineering training at the University of Minnesota, has been with the Columbia organization since 1930. Since 1937 he has been in the Chicago sales office, serving as acting district sales manager for the last 6 months. He assumed his new post February 1.



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Jaws are drop forged, with milled teeth, are heat-treated and extremely tough. They have inner lugs which increase the bearing on the bar and also prevent chains from jamming. Other strength features include forged handles, large hardened steel bolts, alloy steel shackles and proof-tested chains.

ARMSTRONG BROS. Tongs come in *all* standard types, each in *all* sizes.

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"The Tool Holder People"
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These oil-proof, wear-resistant, plastic tubing protectors are an integral part of the tubing collar. Made in all sizes, they prevent the metal-to-metal contact that has caused many expensive "wet" jobs in pumping wells in the past.

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No. 3480. 100 c. c. machine. Cranks and heads interchangeable with 15 c. c. machines.

You can maintain your required speed for the period of the test with much less effort. Curtin centrifuges, proven world-wide, are heavy duty, rigidly constructed, and extremely simple in design. Illustrated bulletin, giving full details, available upon request.

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Dresser buys Kobe

Stockholders of Kobe, Incorporated, Huntington Park, California, approved at a special meeting the transfer of the assets and business of the company to Dresser Industries, Inc., Cleveland, Ohio, for 34,594 total shares of Dresser stock. Dresser directors had previously agreed to this transaction on December 8.

With the addition of Kobe, the Dresser companies on the west coast will total three.

Kobe, Incorporated, is a manufacturer of hydraulic oil well pumping systems.

Honors employes

Presentation of certificates and emblems was made recently to 56 workers of the D. McDonald and Company works of American Meter Company who have been with the company's Albany, New York, plant for 25 years or more. Norton McKean, president and general manager of American Meter Company, announced the organization of a "Twenty-Five Year Service Guild," formed to honor those employes.

The 56 whose services were commemorated have a combined employment record of 1961 years. The oldest employe, Bernard H. Holtslag, has been a meter maker for 58 years. A close second, James Amesmaier, has a record of 54 years of service.

In his address to the employes McKean commented that the company is now devoting 71 per cent of its operations to war work, and the balance to essential meter and meter maintenance orders.

Fourth award

The Lufkin Rule Company, Saginaw, Michigan, has received word from Under-secretary of War Patterson that the Army-Navy production award for outstanding achievement in producing materials for war had been bestowed for the fourth time. This authorizes the company to add the third white star to its Army-Navy "E" flag.

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Apply RECTORSEAL with a brush or swab to threads and gaskets directly from the container . . . no stirring . . . no mixing.

It retains its plastic elasticity, sealing off every crack and crevice for the life of the connection. And when breaking-out, the connection will not be "frozen," because RECTORSEAL keeps its lubricating qualities as well as sealing properties indefinitely.

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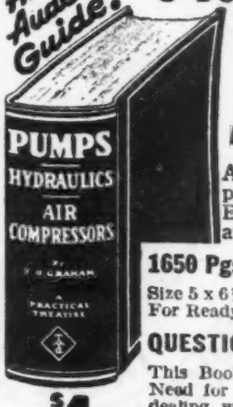

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Employed by_____ P21

Firm change

Skinner Brothers Company, Tulsa, Oklahoma, effective February 1, will take over the business formerly transacted under the name of R. W. & P. B. Skinner.

Junior AIME meeting

"Completion Methods" was the subject of the January meeting of the Southern California Section, Junior Division, AIME group. W. A. Clark of The Texas Company organized the meeting. The speakers were R. A. Holman, Amerada Petroleum Corporation; E. A. Armbruster, Shell Oil Company, and T. W. Bell, The Texas Company. Seventy-five members and guests attended.

Completions with special muds, with wire wrapped screen, and with gun perforations were discussed. Examples were given of successful completions with each of these methods. Bell described the preparation and use of an impermex low water loss mud that resulted in well performance equivalent to that obtained with oil base mud completions in the same area. Armbruster discussed the successful completion with wire wrapped screen of wells in numerous San Joaquin Valley fields where sand production was excessive. An example was given of a completion in the South Belridge field where, before the use of wire wrapped screen, the well was producing half sand. Holman told of his experiences with well completions using gun perforations. Gun perforating is advantageous because of its versatility in the choice of completion depth, he said.

Error baffles readers

A graph printed upside down disconcerted a number of readers of *The Petroleum Engineer* for January, 1945. The graph shown here is a reproduction right side up and will give a better idea of the tetraethyl lead curves of 12-lb. natural gasolines. To keep the record straight this should be cut out and pasted over the figure on page 98.

The excellent discussion, which had the error in publication, was "Postwar Problems of the Natural Gasoline Industry" by Frank E. Fisher, James W. Vaiden, and Justus O'Reilly of the Skelly Oil Company. The article has been reprinted in correct form and a copy will be sent upon request.

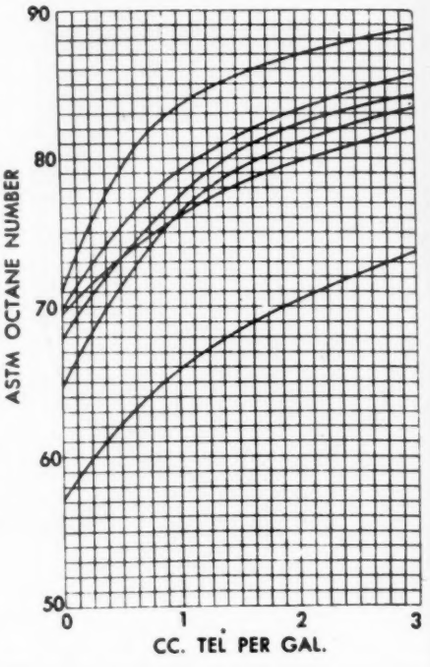
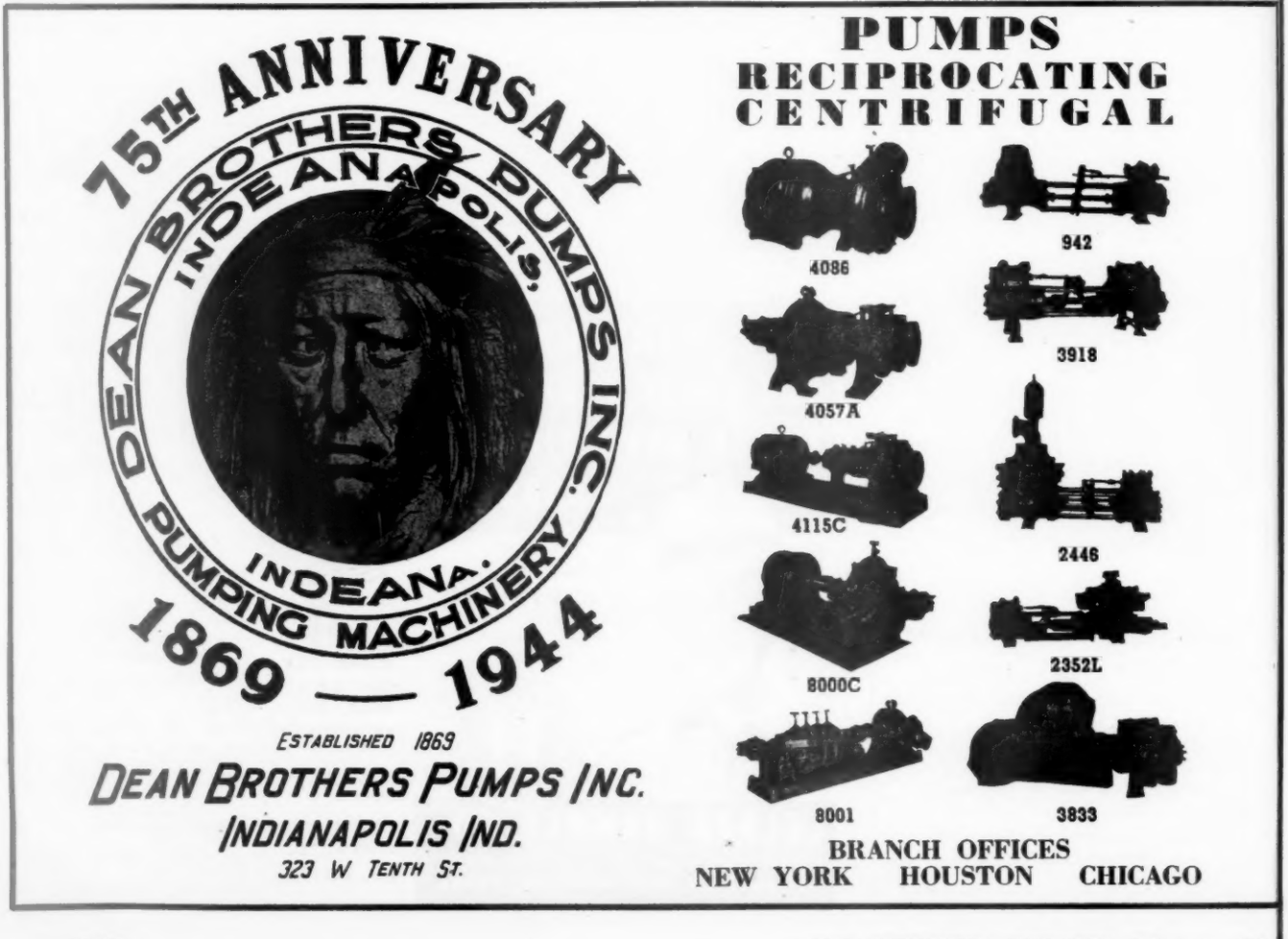


FIG. 1
Tetraethyl lead curves of 12-lb. natural gasolines

Retirement income

The recently inaugurated retirement income plan on behalf of employes of Baker Oil Tools, Inc., marks another important step in the history of this forward-looking organization.

Participation is entirely voluntary by employes of 3 years standing, the company paying the major part of the cost by deposits in a trust fund. No monies deposited by the company are recover



able by it, and under no circumstances shall funds be used except for the exclusive benefit of participants and their beneficiaries.

Benefits based upon a large group basis are far beyond those obtainable by the employe acting as an individual, and a sum far in excess of his contributions is payable to an employe leaving service of the company after several years of participation in the plan.

In his letter of announcement, President R. C. Baker says in part: "The security offered by the plan should serve to keep us at a high standard at all times, and as we maintain that high standard I want each employe to participate in the company's success."

Firm organized

The organization of Falcon Products, Inc., manufacturers of slush pump repair parts, is announced by Jack Pike, president of the company.

Products of the company are being marketed under the name "Falcon" and are distributed in California and other domestic oil producing areas exclusively through supply stores.

General manager of Falcon Products, Inc., is H. F. Schlittler who is also vice president of the company. Schlittler was formerly with Abegg and Reinhold where he served for more than 14 years. The secretary-treasurer of the company, Hugh Kirkwood, who also holds the post of production manager, was with Republic for 20 years before joining Falcon Products, Inc.

Brooksieker promoted

The Kaydon Engineering Corporation, Muskegon, Michigan, announces the appointment of Herman H. Brooksieker as vice president in charge of manufacturing. Brooksieker for the last 7 years was vice president and superintendent of Pesco Products Division of Borg-Warner Corporation, Cleveland, Ohio.

H. H. Brooksieker

Other connections during the last 25 years were production manager at Marquette Metal Products Company, Cleveland, Ohio; general superintendent, Hupp Motor Car Company, Cleveland and Detroit; superintendent and production manager, Chandler Motor Car Company, Cleveland. He also spent several years with the Warner-Swasey Company and the Cleveland Automatic Machine Company prior to enlisting as a private in World War 1, where after 16 months' service overseas he rose to the rank of captain.

New division office

Core Laboratories, Incorporated, in Dallas announce the opening of a new division office in Jackson, Mississippi. The new office is in the John Hart Building with Ralph W. Parnell, division engineer, in charge. James A. Lewis, president of Core Laboratories, who made the announcement said that the new office is the ninth division office and additional ones will be announced later.

Open regional office

G. M. (Tid) Guilbert has been appointed manager of the Twin Disc Clutch Company's newly-created regional office at Lansing, Michigan, according to an announcement by N. F. Adamson, general sales manager for Twin Disc. The new territory formerly was served from the Cleveland regional office.

Guilbert is a 20-year veteran with the Twin Disc Clutch Company, having served this concern in various important executive capacities. Due to his widespread acquaintance among manufacturers and his intimate knowledge of Twin Disc products and their applications, he was considered an ideal choice for this important new assignment. Just prior to his appointment as manager of the Michigan region, Guilbert completed an extensive nation-wide survey to determine the future requirements of equipment for the transmission and control of power in industrial applications.

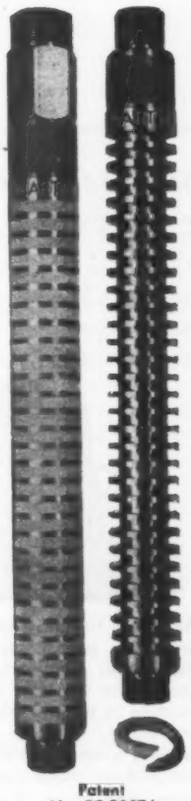
Executive offices for the new region are situated at 2200 Olds Tower Building, Lansing 8, Michigan. According to Guilbert, a complete engineering service for Michigan manufacturers will be provided by the regional office.

Operations are Smooth When You're "In The Groove" with MARTIN PLUNGERS

Just as the Tough and Resilient Martin Composition rings are in the machined grooves of the strong and durable one-piece Martin Plunger bodies, you too will be "in the groove" for longer pump runs and less overall lifting cost, when you use Martin Plungers.

Because the Martin Plunger is the only correctly engineered ring plunger for deep wells, it is likewise more efficient in the shallower wells.

Martin Plungers are made for all sizes of working barrels and Rod Pumps and in many lengths for various depths. They are furnished in Brass or Stainless Steel where corrosive conditions require these metals.



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More than 25 years ago we thought the cost of producing a barrel of oil too high. We founded a business to solve that problem. Producers have helped. The business has grown—amazingly.

Everything we have learned about dependable, efficient pumping equipment is now incorporated in JENSEN Units, and you see JENSEN Units bobbing away in fields from coast to coast and Gulf to Great Lakes. If your cost of lifting a barrel of oil is low, we have every reason to believe we can make it lower.

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As clutch building specialists, with over a quarter century of experience, we study your product designs and recommend the BEST clutches for your particular needs. We then have the facilities to produce those clutches on a basis that will strengthen the competitive position of your products — as to power, control, size, weight, service and price. BRING YOUR CLUTCH PROBLEMS TO US — By sending your specifications to us NOW, your clutch needs can be met without unnecessary delay — when reconversion starts

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It shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacitity tables, dimensions and complete specifications. Every production engineer will find help in this handy bulletin, when planning postwar products.

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ROCKFORD CLUTCHES

Superintendents meet

Those in attendance at a recent meeting of the district superintendents of Homco cutting and fishing tool department, are shown in the accompanying photograph. At this meeting, discussion centered around wartime service to the petroleum industry and how Homco could better aid in the emergency field of cutting and fishing.

Reading left to right, back row: J. M. "Pat" Patterson,

Odessa, Texas; D. U. "Doc" Skinner, public relations, Houston, Texas; Geo. E. Justice, vice president, Houston; H. E. "Red" Golemon, Corpus Christi, Texas; R. G. "Doc" Alford, New Iberia, Louisiana; Earl Sawyer, Magnolia, Arkansas; T. C. "Tommie" Smith, superintendent, Houston, and Ross Andress, Houma, Louisiana.

Front row: L. A. "Lubie" Martin, assistant superintendent, Houston; G. E. "Dutch" Matter, Long Beach, California; Walter Harrison, Corpus Christi; C. G. "Squeegee" Wheeler, Eastern Venezuela, and L. F. Jeter, chief clerk, Houston.

Export representatives

The Tulsa Boiler and Machinery Company, Tulsa, Oklahoma, announces the appointment of Edward L. Carter and associate, Dermont T. O'Connor, as export representatives with offices at Room 1940, 30 Rockefeller Plaza, New York 20, New York.

Visit West Edmond field

Thirty-five advanced students of Petroleum Engineering at the University of Oklahoma toured the West Edmond oil field on Friday, February 2, under the supervision of W. F. Cloud, professor of petroleum engineering. The trip was made to obtain data regarding the drilling and operating methods used in that area.

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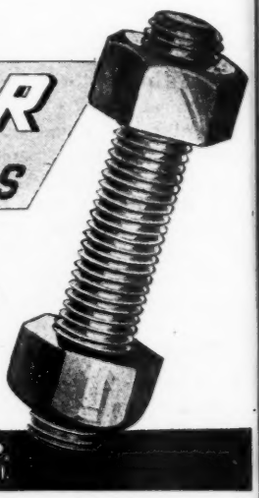

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E. F. Lunken passes

Eshelby F. Lunken, president of The Lunkenheimer Company, Cincinnati, Ohio, valve manufacturers, died suddenly January 25, 1945, of a heart attack. He was 54 years of age.

At the time he was stricken, Lunken was making preparations to attend the annual dinner of the National Association of Manufacturers as a guest of honor, The Lunkenheimer Company having been one of the Cincinnati firms that founded the NAM.

Lunken was a leader in business and civic affairs and was actively interested in aeronautical development, having been a moving spirit in the establishment of Lunken Airport. He also worked closely with the committee for economic development, of which he was a member.

Lunken was a son of Edmund H. Lunken, who at the time of his death in July, 1944, was chairman of the board. E. F. was connected with The Lunkenheimer Company for 35 years and served as president 26 years. He was a grandson of Frederick Lunkenheimer, founder of the company.

Associate director research

Clinton R. Hanna, inventor of the tank-gun stabilizer that enables allied tanks to fire accurately while in motion, has been appointed an associate director of the Westinghouse Research Laboratories it was announced by Dr. L. W. Chubb, director of research.

Hanna, who is also manager of the electro-mechanical department of the research laboratories has been associated with Westinghouse since 1922 in the development of new apparatus, and he has inventions covered by more than 80 patents in the United States and foreign countries. For his work in the development of the tank gun stabilizer, he was awarded a Presidential Citation in 1942.

N. Y. Nomad officers

The New York chapter of Nomads has elected the following officers for 1945: E. H. Trammel, president; W. G. Foster, vice president; R. M. Dinges, secretary; C. R. Tunell, treasurer; H. J. McAdams, sergeant-at-arms; J. W. Reed, assistant secretary; E. L. Carter, assistant treasurer; G. V. Leece, deputy sergeant-at-arms; W. H. Siems, regent and W. J. Campbell, regent.

Testing laboratory

A laboratory for testing domestic heating fuels will be constructed by the Socony-Vacuum Oil Company, Inc., at 412 Greenpoint Avenue, Brooklyn. The laboratory is expected to be in operation early in the spring.

The laboratory will be a one-story, three-room building and will have the necessary facilities for studying the practical performance of fuel oils in commercial burners. Emphasis will be on adaptation of the newer refining processes for the production of fuel oils that will perform economically and satisfactorily in present and postwar burners.

The laboratory also will be used by company engineers and salesmen for instruction so that the best service may be given to fuel oil consumers.

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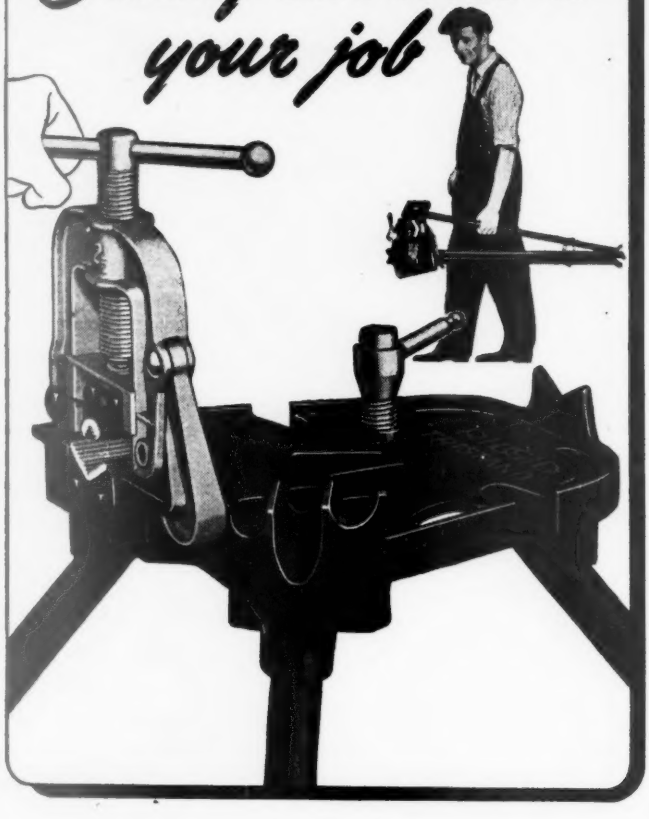

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● This roomy Tristand folds up snugly, carries easily, sets up solid anywhere you need it. Screw-down feet and ceiling brace if you want them. Lots of space for oil can and dope pot, plenty of slots to hang tools. It has a pipe rest and 3 handy pipe benders — and an efficient vise with LonGrip jaws, easy on polished pipe. Buy it for easier work — at your Supply House.

Tristand Chain Vise.

RIDGID

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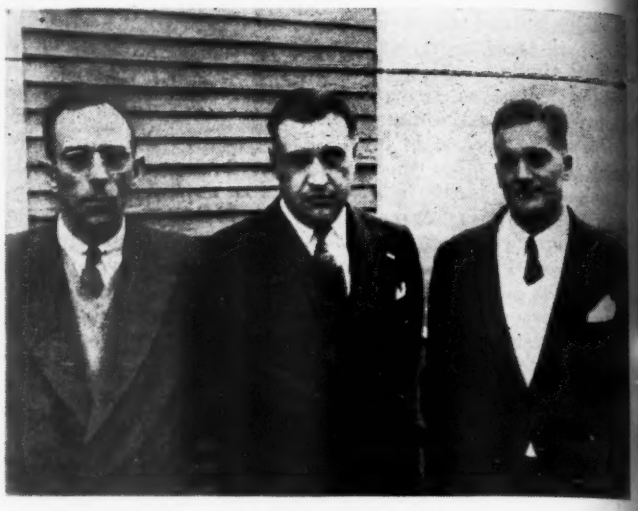
THE RIDGE TOOL COMPANY · ELYRIA, OHIO, U. S. A.

Distributor appointed



Principal officials of Simson-Maxwell, Ltd.: Joseph Simson (left), and Robert Maxwell (right), who are shown with Robert Jones, Cooper-Bessemer Pacific Coast manager of marine sales.

Appointment of Simson-Maxwell, Ltd., of Vancouver, as British Columbia representative of The Cooper-Bessemer Corporation, Mount Vernon, Ohio, has been announced by Stanley E. Johnson, director of sales.

The new distributor will handle all Cooper-Bessemer vertical diesels, both marine and stationary, ranging from 200 to 1900 hp., the GAW horizontal stationary diesel engine, and the Type GX3A air starting units in the British Columbia territory.

Simson-Maxwell is well known in the area it serves by reason of its activities in the marine, mining, and lumber industries in connection with diesel sales and service.

K. Marshall Fagin new member The Petroleum Engineer Staff

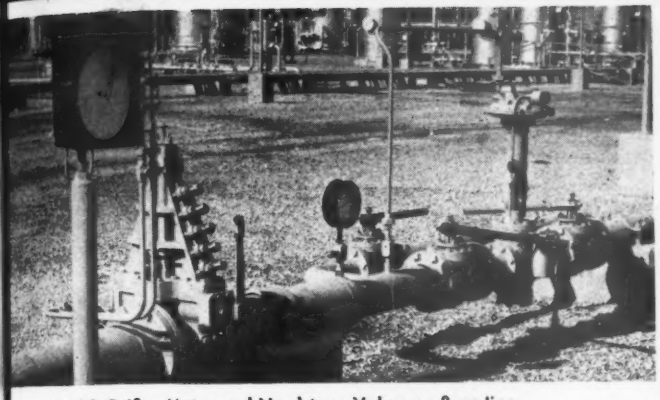
The Petroleum Engineer takes pleasure in announcing that Kyle Marshall Fagin, a petroleum engineer with 15 years' practical and professional experience in the oil and gas industry, has accepted the new position of Field Editor. He will make his headquarters in Dallas.

K. Marshall Fagin

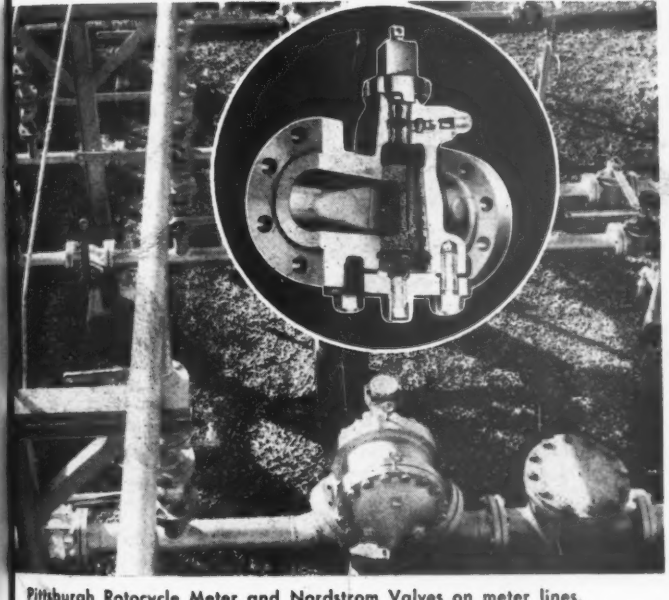
Fagin was born 36 years ago in Amelia, Ohio, and attended school in Cincinnati and Chicago. In addition to carrying undergraduate work at the University of Illinois in geology and engineering and earning his way, he found time to work on the Daily Illini, the campus newspaper, of which he was editor in 1928-1929.

After graduating in June, 1930, he became a roustabout with Shell in the Seminole area of Oklahoma as a trainee engineer. This was followed by scouting, field office, and civil engineering work for Tidewater in the East Texas field. Later he joined the Stanolind Oil and Gas Company in the same field where he became an assistant petroleum engineer, and since 1935 he has been a petroleum engineer and assistant to D. V. Carter, chief petroleum engineer of Magnolia Petroleum Company.

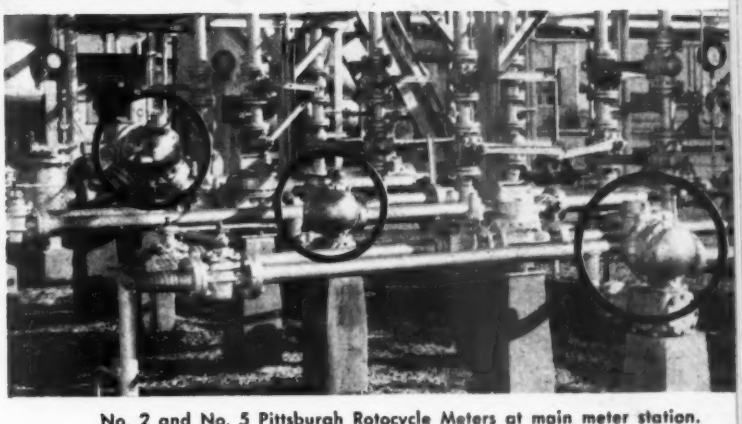
Some of his professional experience has included co-authorship of "Development and Production in East and East Central Texas in 1942" for the 1943 edition of the AIME yearbook on Petroleum Development and Technology. Also, he has devoted much time to the study of oil and gas reserves of all fields in the Mid-Continent. He was a member of the API reserve committee for Oklahoma and Kansas, and served on similar committees for North and West Central Texas and South Louisiana. He has testified in a number of cases before the various state and federal regulatory bodies, and attended many operators and engineering committee meetings dealing with cycling, waterflooding, repressuring, and other production problems.



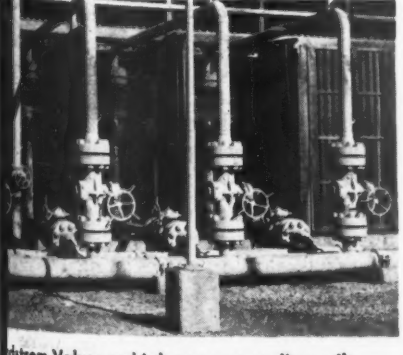
EMCO Orifice Meter and Nordstrom Valves on flare line.



Pittsburgh Rotocycle Meter and Nordstrom Valves on meter lines.

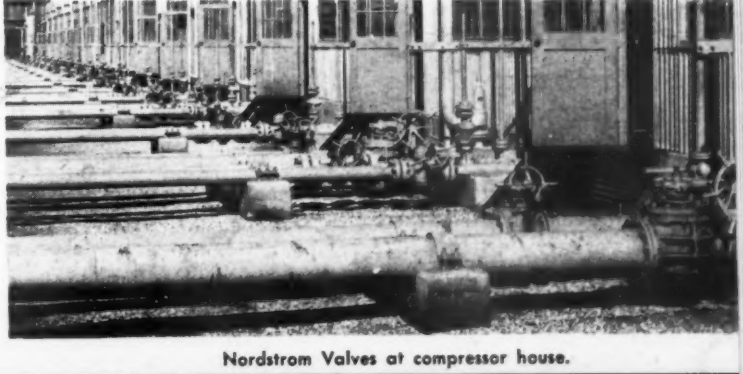


No. 2 and No. 5 Pittsburgh Rotocycle Meters at main meter station.



dstrom Valves on high pressure cooling coils.

KEEP
UPKEEP
DOWN



Nordstrom Valves at compressor house.